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Effect of pH on the Release of Radionuclides and Chelating Agents from Cement-Solidified Decontamination Ion-Exchange Resins Collected from Operating Nuclear Power Stations

Prepared by
C. V. McIsaac, D. W. Akers, J. W. McConnell

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EG&G Idaho, Inc.

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The State Department of Education
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of your letter of the 14th inst.
and in reply to inform you that the
same has been forwarded to the
proper authorities for their consideration.

Very respectfully,
The State Department of Education

By the Secretary,
The State Department of Education

Enclosed for your information are

the following documents:
1. A copy of the report of the
Commissioner of Education for the
year 1916.
2. A copy of the report of the
Board of Education for the
year 1916.

Very respectfully,
The State Department of Education

ABSTRACT

Data are presented on the physical stability and leachability of radionuclides and chelating agents from cement-solidified decontamination ion-exchange resin wastes collected from two operating commercial light water reactors. Small-scale waste-form specimens collected during solidifications performed at the Brunswick Steam Electric Plant Unit 1 and at the James A. FitzPatrick Nuclear Power Station were leach-tested and subjected to compressive strength testing in accordance with the Nuclear Regulatory Commission's "Technical Position on Waste Form" (Revision 1). Samples of untreated resin waste collected from each solidification vessel before the solidification process were analyzed for concentrations of radionuclides, selected transition metals, and chelating agents to determine the quantities of these chemicals in the waste-form specimens. The chelating agents included oxalic, citric, and picolinic acids. In order to determine the effect of leachant chemical composition and pH on the stability and leachability of the waste forms, waste-form specimens were leached in various leachants. Results of this study indicate that differences in pH do not affect releases from cement-solidified decontamination ion-exchange resin waste forms, but that differences in leachant chemistry and the presence of chelating agents may affect the releases of radionuclides and chelating agents. Also, this study indicates that the cumulative releases of radionuclides and chelating agents are similar for waste-form specimens that decomposed and those that retained their general physical form.

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ACRONYMS

ANS	American Nuclear Society	INEL	Idaho National Engineering Laboratory
ANSI	American National Standards Institute		
AP	alkaline permanganate	LOMI	low oxidation-state transition-metal ion
ASTM	American Society for Testing and Materials	LWR	light water reactor
BGW	Barnwell ground water	NP	nitric acid permanganate
BTP	Branch Technical Position	NRC	U.S. Nuclear Regulatory Commission
BWR	boiling water reactor	PCRS	primary coolant recirculation system
CFR	cumulative fraction release	RHR	residual heat removal
DW	demineralized water	SW	seawater
HGW	Hanford ground water	TRU	transuranic
HPGe	hyper-pure germanium	UV	ultra violet
IC	ion chromatography	VES	vinyl ester-styrene
ICP-AES	inductively coupled plasma-atomic emission spectroscopy	w/c	water-to-cement

EFFECT OF pH ON THE RELEASE OF RADIONUCLIDES AND CHELATING AGENTS FROM CEMENT-SOLIDIFIED DECONTAMINATION ION-EXCHANGE RESINS COLLECTED FROM OPERATING NUCLEAR POWER STATIONS

EXECUTIVE SUMMARY

The U.S. Nuclear Regulatory Commission (NRC) is concerned with the safe disposal of low-level chemical decontamination wastes and has made provisions for their disposal in "Licensing Requirements for Land Disposal of Radioactive Waste" (U.S. Code of Federal Regulations Standard 10, Part 61). Section 61.56 provides requirements for the stability of waste forms, which must be met for the waste form to be acceptable for near-surface disposal. Low-level wastes from light water reactors (LWRs) are routinely solidified at LWR sites using hydraulic cement. Solidification of these wastes is intended to provide the needed structural stability to ensure that no subsidence of the disposal trench occurs and that the release of radionuclides via leaching is minimized.

Test procedures to demonstrate waste form stability and to quantify leachability for the low-level wastes from LWRs have been specified by the NRC in the Low-Level Waste Management Branch's "Technical Position on Waste Form." The purpose of this research study is to evaluate the stability of actual low-level radioactive decontamination ion-exchange resin wastes solidified in cement using tests from the NRC's "Technical Position on Waste Form" (Revision 1) for compressive strength, immersion, and leachability, and to determine the release rates of radionuclides, chelating agents, and transition metals from solidified decontamination ion-exchange resin wastes that have been immersed in deionized and simulated ground water and in simulated seawater.

Untreated decontamination ion-exchange resin wastes and small-scale waste-form specimens were collected at the Brunswick Steam Electric Plant Unit 1 and from the James A. FitzPatrick Nuclear Power Station. Primary system piping at the two power stations had been chemically decontaminated using the Citrox/AP/Citrox and LOMI/NP/LOMI processes, respectively. Citrox/AP/Citrox process reagents include citric acid, oxalic acid, and alkaline permanganate. The LOMI/NP/LOMI process reagents include picolinic acid and nitric acid permanganate. Ion-exchange resin wastes were solidified in Portland Type I-pozzolanic (P) cement at both power stations. Cation and mixed-bed resin wastes were solidified separately at Brunswick Unit 1 while only mixed-bed resin waste was solidified at the FitzPatrick Station. Three waste-form specimens collected from the FitzPatrick Station were prepared and then baked for 4 h to assess the effects of elevated temperature on stability. The remaining specimens were cured at ambient temperature.

Samples of each of the three types of waste forms were leached in deionized water, simulated ground waters for the Hanford and Barnwell waste sites, and simulated seawater. Of the cation and mixed-bed resin waste-form specimens from Brunswick Unit 1 that were leach tested, all but the specimens leached in synthetic seawater crumbled into loose granular rubble during the first week of leaching. The FitzPatrick samples all developed severe cracks within a few hours and lost waste form stability. In addition to the variation in leachants, two FitzPatrick samples

that were baked early in the curing process were leached. Both of these samples began to decompose to granular rubble soon after being placed in the leachant.

The following sections discuss the principal observations developed during the leach-testing program that relate to the effects of leachant and waste form composition on the release of radionuclides, chelating agents, and stable metals from the waste forms.

Loss of Waste Form Stability During Leaching

All of the Brunswick Unit 1 waste-form specimens, except those that were leached in seawater, completely decomposed during leach testing. All five FitzPatrick waste-form specimens that were cured at ambient temperature cracked during leach testing, and the two FitzPatrick waste-form specimens that were baked during curing completely decomposed during leach testing. Decomposition of all waste-form specimens occurred early in the leaching program and indicate the presence of a gross physical effect that resulted in decomposition. From the data developed during this study, it has been concluded that the loss of waste form stability during leaching may have been the result of either leachant or chelating agent chemical effects that resulted in the swelling of resin beads to an extent that the waste-form specimen decomposed.

The fact that the samples leached in seawater maintained their general physical form has been attributed to two factors: the formation of an osmotic condition between the resin bead and the high ionic strength leachant, which reduced the swelling associated with the resin beads; and the formation of a mineral surface layer of calcium carbonate and other minerals that passivated the surface of the seawater waste form. These effects tended to reduce the bead swelling and consequently protected the waste-form specimen from decomposition.

Leachate pH and Conductivity. Conclusions from the evaluation of pH and conductivity

measurements for the Brunswick Unit 1 and FitzPatrick waste-form samples are that the chemistry of the waste-form quickly (within several minutes) affects the pH of the surrounding leachant and that the leachate quickly reaches an equilibrium pH. Leachate pH and conductivity measurements for the Brunswick Unit 1 and FitzPatrick waste forms showed that the initial pH and conductivity of a leachant had little effect on the final pH and conductivity, probably because of the large quantity of calcium hydroxide available in each waste form. The pH of leachates reached near-equilibrium values within minutes following waste-form specimen immersion, and the final pH of leachates other than seawater were essentially identical, generally ranging between 11 and 12.

The lower final pH of seawater leachates was likely due to the buffering effect of the chemicals in the seawater leachant. The formation of a reaction rim of calcite on the surface of the waste-form specimens leached in seawater may have also affected the release of calcium hydroxide in the waste-form specimen. No substantive differences in releases of radionuclides, transition metals, and chelating agents were observed that could be attributed to differences in initial or final leachate pH.

An exception to this behavior is when the leachant has a high ionic strength (e.g., seawater) in which the pH of the leachant is probably chemically buffered to a lower pH than the waste form. No substantive differences in the releases of radionuclides and chelating agents were observed as a result of a reduction in pH caused by buffering.

Releases of Radionuclides. In the evaluation of the releases of radionuclides, it was concluded that several factors affected the release of radionuclides. Deionized water is comparable to or more aggressive than ground waters and seawater with an exception. That exception is that ground waters with substantial amounts of calcium carbonate and sulfuric acid (Hanford ground water pH 8.9) seem to increase the release rate from the waste-form specimen possibly due to the establishment of an equilibrium between

the radionuclide (^{60}Co specifically) and the leachate. A comparison of the releases from the AP/Citrox and LOMI waste-form specimens indicates greater releases of most radionuclides from the LOMIs.

A primary conclusion of this work is that it appears that chelating agents cause substantial increases (10^1 – 10^2) in the release rate of all decontamination-produced radionuclides, possibly through the formation of a complex between the chelating agent and the radionuclide. It also appears that citric acid and oxalic acid (Citrox decontamination) are less effective (typically a factor of 10) than picolinic acid (LOMI decontamination) at increasing the leachability of most radionuclides from the waste form. Further work needs to be performed to evaluate the chemistry of these interactions and to fully confirm the mechanisms involved that appear to increase the leachability of the various radionuclides.

Further observations that can be made concerning the release of radionuclides are that there are radionuclide-specific differences in leachability. Typically, the magnitude of the leachability of the radionuclide varies by radionuclide. These studies suggest that the leachability of ^{55}Fe is similar to that of ^{60}Co and both appear to be significantly affected by the presence of chelating agents. In contrast, the release of ^{63}Ni appears to be less influenced by the presence of chelating agents. Other radionuclides, such as the fission products ^{137}Cs and ^{90}Sr follow different release patterns than do the activation products, and there are little or no effective differences in the releases as a result of changes in the composition of the leachant. The absolute and fractional release rates vary substantially between waste-form specimens. The absolute release rates from the Brunswick-1 samples for ^{55}Fe , ^{63}Ni , ^{60}Co , and ^{137}Cs typically range from 10^{-10} through 10^{-11} $\mu\text{Ci}/\text{cm}^2\cdot\text{s}$, whereas the absolute release rates from the FitzPatrick samples ranged from 10^{-7} through 10^{-8} $\mu\text{Ci}/\text{cm}^2\cdot\text{s}$. The differences between the Brunswick-1 and FitzPatrick absolute release rates primarily reflect differences in the inventories of radionuclides in these samples.

In contrast, the fractional release rates from the Brunswick-1 waste-form specimens range from 10^{-9} to 10^{-14} $\text{F}/\text{cm}^2\cdot\text{s}$, and the fractional release rates from the FitzPatrick samples range from 10^{-9} through 10^{-11} $\text{F}/\text{cm}^2\cdot\text{s}$. Consequently, the release rates from the FitzPatrick waste-form specimens can be considered to be greater in both absolute and fractional terms. In addition, there are 10^1 – 10^2 differences in both absolute and fractional release rates that are leachant- and radionuclide-specific.

The leachability indexes for the principal radionuclides ^{60}Co , ^{63}Ni , and ^{55}Fe were compared for the three waste-form specimens tested and for the Cooper mixed-bed and cation resin samples that were tested in a previous study at this laboratory.

A comparison of the ^{60}Co leachability indexes indicates that only the FitzPatrick mixed-bed resin waste-form leachability indexes were effectively lower than the indexes of the other waste forms. It is important to note that this was the only sample in which the chelating agent used was picolinic acid, whereas the other waste forms containing chelating agents, the Brunswick Unit 1 and Cooper mixed-bed waste forms, used citric acid and oxalic acid. These data suggest that the presence of the chelant, picolinic acid, may substantially reduce the leachability indexes for ^{60}Co . The leachability indexes for ^{63}Ni were similarly affected for deionized water.

In contrast to the previous two radionuclides discussed, the leachability indexes for ^{55}Fe were reduced in all of the mixed-bed resin waste forms and in the Cooper cation resin waste form. These data show that the ^{55}Fe behaves differently than do the other radionuclides in the presence of anion resin and chelating agents. If the principal effect is assumed to be due to the presence of chelating agents, the release of ^{55}Fe is affected by all of the chelating agents used.

Release of Chelating Agents. It was determined that the cumulative fractional releases and fractional release rates of picolinic acid are greater (10^1 – 10^2 greater) than the fractional release rates of the chelating agents, citric and

oxalic acids, and in fact at higher levels than any other species. It is suggested that the chelating agent picolinic acid forms complexes with some radionuclides (e.g., ^{63}Ni and ^{137}Cs) and causes substantial increases in the releases from waste forms containing this chelating agent. Further work is needed to define the release mechanism and to define the extent of potential releases from the waste form.

Release of Stable Metals. The releases of stable metals to the leachates were basically below the detection limit for the instrumentation used except for nickel. It was concluded that the leachability of stable nickel was very similar to that of ^{63}Ni . The substantial release of nickel from the FitzPatrick waste forms may be due to formation of some complexes between this element and the chelating agent picolinic acid as with ^{63}Ni .

Compression Testing. The evaluation of the compression tests for the Brunswick and FitzPatrick samples indicated that all Brunswick-1 and FitzPatrick Branch Technical Position (Revision 1) criteria of 500 psi, except

the action resin specimen from Brunswick-1, which had a compressive strength of 392 psig. However, all leached samples either decomposed or lost structural stability, which indicate that compression testing of unleached samples does not provide information on the stability of the waste form after immersion.

In summary, the results of this study suggest that the cumulative releases of radionuclides from waste-form specimens that decomposed is similar to the release from specimens that retained their general physical shape and that the effects of waste-form composition on resin dehydration during solidification, followed by hydration upon leaching and leachant chemical composition should be better evaluated to assess these effects on waste form stability. The effects of chelating agents on releases from waste forms should be further evaluated as this may be the most important effect in the release of radionuclides from cement-solidified waste forms. The effects of various chelating agents on various radionuclides should be studied with particular emphasis on picolinic acid.

INTRODUCTION

During light water reactor operation, the corrosion of fuel rod cladding and other reactor structural surfaces, and the subsequent in-core irradiation of these corrosion products introduces activation products such as ^{54}Mn , ^{55}Fe , ^{60}Co , and ^{63}Ni into the primary coolant. These activation products are transported in the primary coolant throughout the primary system. Some fraction of these activation products adheres to internal primary system surfaces and, over time, can result in the buildup of deposited activity and substantial radiation fields in the vicinities of these surfaces. In order to minimize occupational exposure during primary system maintenance and inspection activities, chemical decontamination methods are now commonly employed to remove activation products from primary system internal surfaces.

The Citrox and LOMI (Low Oxidation-State Transition-Metal Ion) processes are among the most frequently used chemical processes used for the decontamination of primary system components. These processes are presented in Appendix A. The reagents used in these processes include chelating agents such as citric acid, oxalic acid, and picolinic acid. Chelating agents are used in decontamination formulas because they form strong complexes with actinides, lanthanides, heavy metals, and transition metals. Generally, these chemical decontamination solutions, once used, are treated with ion-exchange resins to extract soluble metals and chemicals from the solutions; these resins constitute the final waste to be processed and disposed. Wastes from these chemical decontamination processes contain relatively large quantities of chelates or complexing agents in addition to large inventories of radioactive activation and corrosion products. A potential problem with decontamination wastes is the increased solubility of organo-radionuclide complexes formed during the decontamination process.

The U.S. Nuclear Regulatory Commission (NRC) is concerned with the safe disposal of these chemical decontamination wastes and has made provisions for their disposal in "Licensing

Requirements for Land Disposal of Radioactive Waste" (U.S. Code of Federal Regulations Standard 10, Part 61). Section 61.56 provides requirements for the stability of waste forms, which must be met for the waste form to be acceptable for near-surface disposal. Additional requirements for the disposal of chelated wastes are also given in burial site regulations. In Section 61.54, the wastes are classified as Class A, B, or C based on the concentrations of radionuclides in the wastes. Class A solid wastes have lower concentrations and may be segregated without stabilization; however, Class A liquid wastes require solidification or absorption to meet the 10 CFR Part 61 requirement that no free liquid remains in the waste. Class B and C wastes must, however, be structurally stabilized to ensure that the waste form does not degrade and promote slumping, collapse, or failure of the cap or cover of the near-surface disposal trench. In addition, the stability of waste forms limits exposure to inadvertent intruders.

Low-level wastes from light water reactors (LWRs) are routinely solidified at LWR sites using hydraulic cement. Solidification of these wastes is intended to provide the structural stability needed to ensure that no collapse of the disposal trench occurs and that the release of radionuclides via leaching is minimized.

Test procedures to demonstrate waste form stability and to quantify leachability for the low-level wastes from LWRs have been specified by the United States Nuclear Regulatory Commission in the Low-Level Waste Management Branch's "Technical Position on Waste Form" (Revision 0),¹ published in 1983, and in the "Technical Position on Waste Form" (Revision 1),² published in January 1991. Both revisions of the Technical Position specify that small-scale waste-form specimens must be prepared and tested to certify the stability of the full-scale waste form. A range of tests was performed that included compression testing and leach testing of small-scale waste-form specimens.

The NRC's "Technical Position on Waste Form" (Revision 1) stipulates that the small-scale waste-form specimen, after having been immersed in deionized water for a minimum of 90 days, should have a compressive strength of at least 500 psi (3.4×10^3 kPa) when tested in accordance with the American Society for Testing and Materials (ASTM) Standard C39, "Compressive Strength of Cylindrical Concrete Specimens."³ In addition, the Technical Position (Revision 1) stipulates that the small-scale waste-form specimen should have a leachability index greater than six when leach-tested for a minimum of 90 days in accordance with the American National Standards Institute/American Nuclear Society (ANSI/ANS) Standard 16.1, "Measurement of the Leachability of Solidified Low-Level Radioactive Wastes by a Short-Term Test Procedure."⁴ The study documented in this report was conducted using the requirements from the NRC's "Technical Position on Waste Form" (Revision 0) because Revision 1 had not been completed when this work was performed.

The purpose of this research study is to evaluate the stability of actual low-level radioactive ion-exchange wastes solidified in cement using the tests from the "Technical Position on Waste Form" (Revision 1) for compression testing and leachability, and to determine the release rates of radionuclides, chelating agents, and transition metals from solidified ion-exchange resin wastes that have been immersed in deionized and simulated ground waters. This work is identified in the NRC's Low-Level Radioactive Waste Research Program Plan,⁵ which defines a strategy for conducting research on issues of concern to the NRC in its efforts to ensure stability of solidified low-level radioactive waste, leading to safe disposal.

The leachability of these waste forms is evaluated because it is a function of a number of factors including the chemical characteristics of the radionuclide being leached, resin waste chemistry, solidification agent, and final solidified matrix. Burial site hydrology and ground water chemistry also influence leaching rates, as do cyclic wet and dry conditions. The complexity of the interactions that occur among radionuclides,

chelating agents, ground water, and soil introduces uncertainties into the models used to predict the impact of the decontamination resin wastes on the performance of shallow-land burial sites. Therefore, it is important to establish a data base on the stability and leachability of decontamination resin waste forms representative of waste forms commonly generated at operating commercial power stations in leachants representative of the actual disposal site ground waters.

The results of numerous investigations reported in the literature indicate that the rate of radionuclide release from a waste form is influenced by poorly understood interactions related to the properties of the solid and the leaching system. Among the factors that are known to influence the leachability of cement-solidified waste forms are the chemical composition of the cement used, the waste-to-binder ratio, the amount of water used to set the cement, and the presence of additives that are used to accelerate or retard cement hydration. Other factors such as temperature, leachant composition, pH, volume, and residence time may also influence leachability. These factors were discussed in depth at the Workshop on Cement Stabilization of Low-Level Radioactive Waste.⁶ Specific process details and problem wastes were reviewed, including preliminary findings of this work.

Table 1 summarizes some of the important experimental aspects of several leaching studies that have recently been performed on specimens of solidified resins or decontamination solutions.^{7,8,9,10,11,12,13,14,15,16} Common to these studies is an emphasis on more realistic leaching situations involving local ground water,^{7,10,12} seawater,¹² and actual nuclear power plant resin wastes.^{8,9,10,12} In these studies, solidified ion-exchange resin specimens were subjected to leach tests following either the ISO 6961 leach-test procedure¹⁷ or the ANSI/ANS 16.1 leach-test procedure.^{8,9,14,15,16} Both of these methods are nonequilibrium tests in the respect that the solidified waste-form specimen is completely immersed over an extended period of time in a large volume of leachate that is periodically replaced with new leachant.

Table 1. Summary of recent cement-solidified resin waste leach studies

Author	Reference Number	Sample Size	Leachant	Solidification Agent(s)	Resin Type
Criscenti, L. J. Serne, R. J.	7	2.5 cm × 5.0 cm (diameter × length)	Hanford ground water	Portland cement type III	BWR evaporator concentrates and ion- exchange resins
Howard, C. G. Jolliffe, C. B. Lee, D. J.	8,9	28 mm × 28 mm (diameter × length)	Demineralized water	Portland cement, blast furnace slag, microsilica	LOMI ion-exchange resin DOWEX 50X8 ⁶⁰ Co, ¹³⁷ Cs
Ipatti, A. Harkonen, H.	10	Small lab-scale specimens	Ground water	Cement	Spent ion-exchange resins from Loviisa Power Plant
Torstenfelt, B. Hedin, G.	11	Not specified	Not specified	Sulfate resistant Portland cement	Powdered ion- exchange resins with 5 wt.% zeolite
McIsaac C. J. W. Mandler	12	5 cm × 10 cm (diameter × length)	Ground and sea water	Portland cement Type I-P	Decontamination ion-exchange resins IRN-77, IRN-78, C-100-H, and A-600
Bishop, J. V.	13	2 in. × 4 in. (diameter × length)	Compression test only	Portland cement Lime and NaOH	Ion-exchange resins Ionac A-365 and C-267 with picolinic acid only
Davis, M. S. Picuilo, P. L. et al.	14	2 m × 4 m (diameter × length)	Demineralized water	Portland cement Type I and VES	Ion-exchange resins IRN-77, IRN-78, Ionac-365 with chelates only
Lee, J. O. Han, K. W. Buckley, L. P.	15	Not specified	Demineralized water	Cement, polyester resin and Zeoloin 900-Na	Ion-exchange resins, Li ⁺ - DH ⁺ form, ⁶⁰ Co, ⁸⁵ Sr, and ¹³⁷ Cs
Soo, P.	16	5 cm × 10 cm 15 cm × 15 cm 30 cm × 30 cm (diameter × length)	Deionized water Formate and pico- linate solutions	Portland cement Type I and VES	Simulated Decontaminated resin waste

Differences in leaching behavior have been observed in the studies that appear to be a result of changes in leachate composition. A study of the effects of seawater on leach rates of non-resin wastes by Fuhrman and Colombo¹⁸ indicates that release rates were a factor of 10 less than those observed for deionized water. The slower release rates are thought to occur because of the much higher ionic strength of the seawater leachant and cement/waste-leachant reactions. Other factors

that may affect leaching behavior that are being studied include surface film effects, reactions in deeply intrusive pores, precipitate formation, and long-term leaching.

The present study is a continuation of studies^{12,19} previously performed at the Idaho National Engineering Laboratory (INEL) for the NRC that determined the compressive strength and leachability of cement-solidified evaporator

concentrates and decontamination ion-exchange bead resin waste forms leached in deionized water. This study is the only study in which actual commercial nuclear power plant decontamination radwaste is being evaluated.

In the current study, untreated ion-exchange resin wastes and small-scale Portland Type I-P waste-form specimens were collected from solidification vessels during solidifications of ion-exchange resin wastes at the Brunswick Steam Electric Plant Unit 1 and at the James A. FitzPatrick Nuclear Power Station. Citrox/AP/Citrox and LOMI/NP/LOMI decontaminations (see Appendix A) were performed at the two plants, respectively. At Brunswick-1, the cation and mixed-bed resin wastes were solidified separately, whereas at the FitzPatrick Station, only mixed-bed resin waste was solidified. Consequently, three types of waste forms are evaluated as part of this study. In order to assess the effect of leachant chemical composition and pH on the stability and leachability of the waste forms, seventeen small-scale waste-form specimens were leached in deionized water, synthetic seawater with pH 6.4, synthetic Hanford ground

water with pH 8.9, and synthetic Barnwell ground waters with pH 4.2 and 10.4.

The following sections of the report summarize the experimental procedures, the examination results, and the conclusions and recommendations from the testing program. The experimental procedures section includes discussions of the sampling program at the power plants, the leaching and compression testing program, and the analytical methods used to perform the measurements of radionuclide, chelating agent, and transition metal leachability. The experimental results section contains discussions of the leaching and compression testing results and compares the results for the three types of waste forms tested. Finally, the conclusions and recommendations section compares the leaching and compression test results with requirements from the NRC's "Technical Position on Waste Form" (Revision 1), the effects of the loss of waste form stability on the release of radionuclides, and the effect of leachant chemical composition and initial pH on the releases of radionuclides, chelating agents, and transition metals. In addition, recommendations for future studies are also discussed.

EXPERIMENTAL PROCEDURES

Studies reported in the literature indicate that releases of radionuclides^{19,20,21,22} and chelating agents¹⁶ from cement-solidified waste forms closely follow predictions based on classical diffusion models. They show that, for cylindrical samples, the effective diffusivities derived by using the semi-infinite plane source diffusion model do not depend on sample size. In the majority of the leaching studies summarized in Table 1, the smallest samples tested were either approximately 5 × 5 cm or 5 × 10 cm (diameter × height). In order to allow for direct intercomparison of the results of this study with those of other studies, and at the same time minimize exposure hazards and logistical requirements inherent in handling and testing radioactive samples, the waste-form samples collected during this study were approximately 5 × 10 cm right-circular cylinders. The dates of the decontaminations, the processes used, the systems that were decontaminated, and the names of the companies that performed the decontaminations are summarized in Table 2. The dimensions of the specimens that were leach-tested and their volumes, surface areas, and other physical parameters are summarized in Tables 3 and 4.

The following sections describe the methods used to collect the untreated resin waste and waste-form samples, the procedures used to leach the waste-form specimens and perform compressive strength tests, and the analytical

methods used to determine the concentrations of radionuclides, metals, and chelating agents in the untreated resin waste and leachate samples.

Sample Collection

Unsolidified resin waste and cement-solidified decontamination resin waste specimens were collected from two different boiling water reactors (BWRs)—the Brunswick Steam Electric Plant Unit 1 and the James A. FitzPatrick Nuclear Power Station. The Citrox/AP/Citrox process was used to decontaminate the primary coolant recirculation system at Brunswick Unit 1 during December 1987. The LOMI/NP/LOMI process was used to decontaminate the reactor water cleanup system (greater than 90%), the residual heat removal crosstie, and the primary coolant recirculation system (PCRS) at James A. FitzPatrick during September 1988 as shown in Table 2. Descriptions of the two chemical decontamination processes are given in Appendix A. In each case, samples of decontamination resin waste were collected from the solidification liner both prior to and following the addition of Portland Type I-P cement and additives. Specific details of the sample collections at the two BWRs are presented in the following sections.

Brunswick Unit 1. Brunswick Plant Unit 1, a BWR that is rated at 790 MWe, began commercial operation in March 1977. The

Table 2. Chemical decontamination summary

Station Sampled	Date of Decontamination	System Decontaminated	Purpose	Process	Decontamination Contractor	Waste Volume ft ³ (m ³)
Brunswick-1	12/87	PCRS ^a	Pipe inspection	Citrox/AP/Citrox	Pacific Nuclear Services	229.9 (6.51)
FitzPatrick	09/88	RWC ^b	Pipe inspection RHR crossties	LOMI/NP/LOMI	Pacific Nuclear Services	207.6 (5.88)

a. Primary coolant recirculation system.

b. Greater than 90% Reactor Water Cleanup system decontamination wastes with some decontamination of the RHR crossties and the PCRS per John Bishop, Pacific Nuclear, letter to Dan Johnson, September 22, 1988.

Table 3. Physical parameters of ion-exchange resin waste-form specimens collected from Brunswick Plant Unit 1

Sample Identification ^{a,b,c}	Diameter × Height (cm)	Mass (g)	Surface Area (cm ²)	Volume (cm ³)	Volume-to- Surface-Area Ratio (cm)	Resin Loading		
						Wet (vol.%)	Wet (wt.%)	Dry (wt.%)
Cation-D	5.8 × 9.7	341.3	230.3	257.3	1.12	74.6	55.4	19.3
Cation-B	5.8 × 9.9	343.7	232.3	259.7	1.12	74.6	55.4	19.3
Cation-L	5.8 × 9.1	310.0	216.5	236.6	1.09	74.6	55.4	19.3
Cation-H	5.8 × 9.3	304.0	220.0	241.9	1.10	74.6	55.4	19.3
Cation-S	5.9 × 9.0	309.6	219.9	243.3	1.11	74.6	55.4	19.3
Mixed-bed-D	5.7 × 9.2	263.0	182.0	199.2	1.09	71.9	52.8	15.0
Mixed-bed-B	5.9 × 8.8	229.1	178.6	173.5	0.97	71.9	52.8	15.0
Mixed-bed-L	5.5 × 8.5	247.1	205.0	187.2	0.91	71.9	52.8	15.0
Mixed-bed-H	5.6 × 10.0	192.9	184.0	146.1	0.79	71.9	52.8	15.0
Mixed-bed-S	5.8 × 8.7	291.7	233.3	221.0	0.95	71.9	52.8	15.0

a. Letter suffix indicates the leachant used during leach testing:

D = deionized water with pH 7.0

B = synthetic Barnwell ground water with pH 10.4

L = synthetic Barnwell ground water with pH 4.2

H = synthetic Hanford ground water with pH 8.9

S = synthetic seawater with pH 6.4.

b. Samples were cured at ambient temperature for 254 days prior to the initiation of leach testing.

c. Unleached samples were tested for compressive strength after 486 days of cure time; all leached samples disintegrated during testing.

Table 4. Physical parameters of ion-exchange resin waste-form specimens collected from James A. FitzPatrick Station

Sample Identification ^{a,b,c}	Diameter × Height (cm)	Mass (g)	Surface Area (cm ²)	Volume (cm ³)	Volume-to- Surface-Area Ratio (cm)	Resin Loading		
						Wet (vol.%)	Wet (wt.%)	Dry (wt.%)
Mixed-bed-D	4.7 × 9.8	273.2	178.6	168.8	0.95	73.8	52.7	15.0
Mixed-bed-B	4.7 × 9.8	267.4	178.6	168.8	0.95	73.8	52.7	15.0
Mixed-bed-L	4.7 × 9.8	271.5	180.2	171.3	0.95	73.8	52.7	15.0
Mixed-bed-H	4.7 × 9.9	275.1	181.7	173.1	0.95	73.8	52.7	15.0
Mixed-bed-S	4.7 × 9.9	272.7	180.0	170.5	0.95	73.8	52.7	15.0
<u>Baked specimens</u>								
Mixed-bed-D	4.7 × 9.8	269.4	179.9	171.0	0.95	73.8	52.7	15.0
Mixed-bed-L	4.7 × 9.9	270.9	181.2	172.5	0.95	73.8	52.7	15.0

a. Letter suffix indicates the leachant used during leach testing:

D = deionized water with pH 7.0

B = synthetic Barnwell ground water with pH 10.4

L = synthetic Barnwell ground water with pH 4.2

H = synthetic Hanford ground water with pH 8.9

S = synthetic seawater with pH 6.4.

b. All waste form specimens were cured for 119 days prior to leach testing. Two samples were baked for 4 hours at 49°C during the first day of curing.

c. Unleached samples were tested for compressive strength after 212 days of cure time; all leached samples cracked or disintegrated during testing.

Citrox/AP/Citrox process was used to decontaminate the PCRS during December 1987. Decontamination generated 70.0 ft³ (2.12 m³) of Purolite C-100-H cation resin; 75.0 ft³ (2.12 m³) of Citrox mixed-bed resin, which was composed of 10% Purolite C-100-H and 90% Purolite A-6000H anion resin; and 70.0 ft³ (1.98 m³) of AP mixed-bed Purolite NRW-37 resin waste. The three types of ion-exchange resin were solidified in two L14-170 steel liners, each having a

capacity of 169 ft³ (4.79 m³). Thirty cubic feet (0.85 m³) of the AP mixed-bed resin were combined with the cation resin in one liner, and 40 ft³ (1.13 m³) of the AP mixed-bed resin were added to the Citrox mixed-bed resin in a second liner. Because of the chemistry of the processes, only the Citrox mixed-bed resins contained chelates. The resins that were solidified were manufactured by the Mueller/Barnstead Division of the Paul Mueller Co., Burlington, Mass. Slaked lime

(calcium hydroxide) was added to the cation resin waste, and sodium hydroxide was added to the mixed-bed resin waste to raise the pH of the wastes prior to the addition of the Portland Type I-P cement. The Portland Type I-P cement was a proprietary formulation provided by the vendor, Pacific Nuclear Services.

As shown in Table 3, in the case of the cation resin waste, water and resin waste were combined to make up about 75% of the final volume% of the resin/cement mixture, or about 55% of the final mass of the mixture. Using the water contents of "as-received" and dewatered ion-exchange resins reported by Neilson,²³ the ratio of the weight of free interstitial water to weight of cement and slaked lime in the final cation resin waste/cement mixture was 0.27. In the case of the mixed-bed resin waste, water and resin waste together made up about 72% of the final volume% of the resin/cement mixture, or about 53% of the final mass of the mixture, which corresponds to a water-to-cement ratio of 0.30. The loadings of dry ("as-received") resin in the Brunswick-1 cation and mixed-bed resin waste-form specimens were 19.3% and 15.0%, respectively.

Following the thorough mixing of the wastes and binder materials, six waste-form specimens were collected from each liner. These samples were collected by the plant staff; no INEL personnel were present to observe the sampling operation. At the time the samples were collected, the mixed-bed resin/cement paste had begun to set up. Consequently, the mixed-bed waste-form specimens were obtained by scraping the polyethylene waste-form molds across the upper surface of the resin/cement monolith. This sampling technique may have affected the stability of the waste form, as will be discussed in the results section. The cation resin/cement paste remained somewhat fluid throughout the time that the waste-form specimens were collected, which allowed the material to be sampled to a greater depth than was the case with the mixed-bed resin waste.

Photographs of specimens that are typical of the cation and mixed-bed resin waste forms

collected from Brunswick Unit 1, which were taken prior to the start of leaching, are shown in Figures 1 and 2, respectively. Figure 1 shows that the cation resin waste-form specimens prior to leaching were solid right-circular cylinders

Figure 1. Brunswick Plant Unit 1 cation resin waste-form specimen prior to leaching.

Figure 2. Brunswick Plant Unit 1 mixed-bed resin waste-form specimen prior to leaching.

having smooth surfaces with few surface imperfections and no cracks. Figure 2 shows that the mixed-bed resin waste-form specimens were irregular in shape and exhibited cracks in their surfaces. The textures of the surfaces of the mixed-bed resin waste-form specimens were also fairly rough. The condition of the mixed-bed resin waste-form specimens is the result of the fact that the resin/cement paste had begun to set up when the specimens were collected. In all cases, rinsing the waste-form specimens prior to leaching them did not change their appearance.

James A. FitzPatrick. James A. FitzPatrick Station, a BWR that is rated at 778 MWe, began commercial operation in July 1975. The LOMI/NP/LOMI process was used to decontaminate the reactor water cleanup system and the smaller residual heat removal (RHR) service water cross-tie during September 1988. Decontamination generated 117.6 ft³ (3.33 m³) of Ionac A-365 anion exchange resin and 90.0 ft³ (2.55 m³) of Ionac C-267 cation exchange resin. Ionac A-365 is a weakly basic polyacrylate-based anion resin with a gel bead structure. Ionac C-267 is a strong acid styrene-divinyl-benzene polymer-based cation resin that is supplied in the H⁺ form. Both ion-exchange resins are manufactured by Sybron Chemicals, Inc., Birmingham, N.J. The 207.6 ft³ (5.88 m³) of resin waste generated during decontamination was solidified in three different L14-170 steel liners. The cement was a proprietary formulation provided by the vendor, Pacific Nuclear Services.

The liner from which waste-form specimens were obtained contained 60 ft³ (1.70 m³) of Ionac C-267 cation resin and 14.8 ft³ (0.42 m³) of Ionac A-365 anion resin. Because of high radiation levels at the surface of the liner, the transfer of decontamination resins to this liner was halted, and the filling of the liner was completed using relatively low activity mixed-bed ion-exchange resin from the plant radwaste treatment system and charcoal from a plant air purification system. A total of 32.1 ft³ (0.91 m³) of mixed-bed resin and charcoal was added to this liner, making the total volume of waste in the liner 107 ft³ (3.03 m³).

After the mixing apparatus in the liner had been allowed to operate for about 40 minutes, a 3.0 in³ (50 cm³) sample of wet resin waste was obtained from the liner by lowering a plastic vial attached to a rod below the surface of the resin bed. Acquisition of this sample was observed by INEL personnel along with the acquisition of additional resin samples collected by the plant staff that were acquired to prepare process control program (PCP) samples. Slaked lime was then added to the resin waste to raise the pH of the waste prior to the addition of Portland Type I-P cement. As shown in Table 4, water and the resin and charcoal waste together made up about 74% of the final volume% of the waste/cement mixture, or about 53% of the final mass of the mixture. If we assume that the quantity of charcoal added to the liner was small, the ratio of weight of free interstitial water to weight of cement and slaked lime in the final mixture was 0.30.

After the cement had been thoroughly mixed with the waste and the fill-head was removed from the top of the liner, a sampling tool, consisting of a plastic pipe 1.8 m in length equipped with a plunger, was pushed into the resin/cement paste to a depth of about 1 m. These samples, collected by INEL staff, were transferred to a plastic bucket and then to 5.1 cm × 10.2 cm (diameter × length) polyethylene waste-form molds, which were fitted with snap-on, air-tight lids. The sampling was repeated at three different locations on the surface of the resin/cement monolith. Once a waste-form mold was filled, it was sealed. A total of nine waste-form specimens were collected.

Beginning within an hour after their collection, three of the waste-form specimens were baked in an oven for 4 h at 49°C. These waste-form specimens were baked to simulate the high temperatures associated with the cement hydration exotherm inside the full-scale liner. This approximation of the exotherm is not fully representative as will be discussed in the results section. The remaining six waste-form specimens were allowed to be cured at ambient temperature.

The waste-form specimens collected at the James A. FitzPatrick Station were found to be right circular cylinders with no evidence of

cracks or other damage as determined from visual inspection upon the receipt of the samples at the INEL. A representative example of the waste forms collected from the James A. FitzPatrick Station, which was taken just before the start of leach testing, is shown in Figure 3.

Leach-Test Method

The test procedure used to measure the release of radionuclides, transition metals, and chelating agents from decontamination resin wastes solidified in Portland Type I-P cement was ANSI/ANS 16.1, "Measurement of the Leachability of Solidified Low-Level Radioactive Wastes by a Short-Term Test Procedure."⁴ The standard is recommended by the NRC in the "Technical Position on Waste Form"¹ and in Revision 1² of the same document to measure the release of radionuclides from solidified low-level radioactive waste. The standard is intended to provide a means of quantifying the release of radionuclides from waste forms using the results of relatively short-term tests performed in a laboratory. It is not intended to serve as a definition of long-term leaching behavior of waste forms under conditions representing actual burial conditions. The method specified by the standard for analyzing leach test data is based on the assumption that diffusion is the only release mechanism. Other mechanisms such as dissolution, ion exchange, corrosion, cracking, etc., are not incorporated into the models used to describe releases. Although the adequacy of this assumption has been questioned,²⁴ the test procedure is, however, believed suitable to establish a data base on the release of radionuclides in the presence of relatively high concentrations of chelating agents and transition metals.

Test Procedure. The ten waste-form specimens obtained from Brunswick Unit 1 and the five waste-form specimens from the James A. FitzPatrick Station were right-cylindrical solids with nominal dimensions of 5 × 10 cm. The Brunswick Unit 1 samples were cured at ambient temperature for 254 days prior to the initiation of leach testing, and all but two FitzPatrick samples were cured at ambient temperature for 119 days

prior to leach testing. The remaining FitzPatrick samples were baked for 4 h at 49°C during the first day of curing and were then cured at ambient temperature for another 118 days before leach testing. The actual dimensions and the curing times are shown in Tables 3 and 4. All samples were leached in cylindrical polyethylene containers having capacities of about 3 L that were filled to about 1.6 L. Figure 4 shows a representative waste-form specimen suspended in a leach-test vessel. In all cases, the waste-form specimen was supported in the leach-test vessel by coarse mesh plastic netting that was suspended by a wire from the container lid.

Five different leachants were chosen for this study to assess the effects of different ground waters and seawater on leachability. The five leachants used were deionized water having a conductivity of less than 3 µmho/cm at 298 K

Figure 3. James A. FitzPatrick Station mixed-bed resin waste-form specimen prior to leaching.

Figure 4. Leach-test vessel showing waste-form specimen support.

(25°C), synthetic seawater with pH 6.4, synthetic Hanford ground water with pH 8.9, and synthetic Barnwell ground waters with pH 4.2 and 10.4. The chemical compositions of the synthetic seawater and ground water leachants are given in Table 5 along with the references for the formulations used.

Synthetic Barnwell ground water with pH 4.2 was prepared by adding nitric acid to synthetic Barnwell ground water with pH 10.4 until the pH of the solution was reduced to 4.2. Field measurements of trench and well water samples taken from the Barnwell, South Carolina disposal site during 1978 showed that the pH of the water ranged between 5.9 and 11.4,²⁵ and the pH of well water in the vicinity of the Barnwell disposal site has been reported to be as low as 4.5.²⁶ Consequently, the pH 4.2 and 10.4 simulated ground waters bracketed the range reported for ground and surface water in the vicinity of the Barnwell disposal site.

The formula for synthetic Hanford ground water was based on the results of an analysis of Hanford site ground water performed during 1985 (see Reference 5). The pH of the Hanford

ground water was reported to be 8.2, slightly lower than the pH 8.9 of the synthetic Hanford ground water used in this study.

As required by ANSI/ANS 16.1, the ratio of leachant volume to specimen external geometric surface area was kept constant at 10:1. Consequently, the volumes of leachant ranged from 1.7 to 2.6 liters for the different sample sizes. The pH and conductivity of the leachates were measured at the end of each leaching period.

During leach-testing, the requirements established in ANSI/ANS 16.1 were followed. This standard requires a minimum leach period of 90 days, which corresponds with the test period specified in the NRC's "Technical Position on Waste Form" (Revision 0), although the current Revision 1 requirements are for a 5-day leach test. During the period of the 90-day leach testing of the Brunswick Unit 1 and FitzPatrick samples, the required ANSI/ANS 16.1 change-out schedule was maintained with minor exceptions, and the leachant temperature was maintained at $73 \pm 5^\circ\text{F}$ ($23 \pm 3^\circ\text{C}$). The exceptions to the required changeout schedule were that the tenth and final changeouts of leachant samples for the Brunswick Unit 1 and James A. FitzPatrick samples were not performed until 91 days and 98 days, respectively, into the leach-testing period. The 98-day leaching period is not verbatim compliance with the "Technical Position on Waste Form" (Revision 1), but it is not expected to make a significant difference in the cumulative release fractions and leachability indexes for these samples because, as noted in the "Technical Position on Waste Form" (Revision 1), no significant difference exists in the leachability indexes of cement waste forms as determined at 5 or 90 days per the Technical Position on Waste Form. Consequently, the leaching period for the Brunswick Unit 1 and James A. FitzPatrick samples will be treated as nominal 90-day leaching periods in the discussion of the results.

Following the initial 90-day leaching period, leaching of both the Brunswick Unit 1 and James A. FitzPatrick samples was continued to assess

Table 5. Compositions of synthetic leachants (g/L)

Compound	Seawater ^a	Barnwell Ground Water ^b	Hanford Ground Water ^c
CaCO ₃	—	—	2.624
Fe(NO ₃) ₃ ·9H ₂ O	—	0.00069	—
HNO ₃	—	—	0.002
H ₂ SO ₄	—	—	1.647
KBr	0.096	—	—
KCl	0.666	—	0.269
KHCO ₃	—	0.022	—
MgCl ₂ ·6H ₂ O	14.103	—	0.813
MgCO ₃	—	0.088	0.086
NaCl	23.538	—	—
Na ₂ SiO ₃ ·9H ₂ O	—	0.048	2.967
Na ₂ SO ₄	4.087	0.012	—

a. The formula used to prepare synthetic seawater was formula III in Appendix D of the ANSI/ANS 16.1 leach-test procedure.

b. The formula used to prepare synthetic Barnwell ground water was that given in Table 9 of a study by R. Buschbom et. al., *Characterization of Cement and Bitumen Waste Forms Containing Simulated Low Level Waste Incinerator Ash*, NUREG/CR-3798, August 1984.²⁷

c. The formula for Hanford ground water was given by L. Criscenti and R. Serne, *Geochemical Analysis of Leachates from Cement/Low Level Radioactive Waste/Soil Systems*, PNL-6544, September 1988.

the effects of long-term leaching. In the case of the Brunswick Unit 1 cation and mixed-bed resin waste-form specimens beyond 90 days, leachates were changed out at intervals of between 30 and 79 days. After the Brunswick Unit 1 waste-form specimens had been leached 201 days, the long-term leaching of specimens in leachants other than deionized water was discontinued as it was determined that deionized water was the most aggressive leachant. Beyond 201 days, the deionized water leachates

were changed out at intervals of between 28 and 76 days. When leach testing was discontinued, the two specimens in deionized water had been leached a total of 388 days. It should be noted that only the cation and mixed-bed waste-form specimens leached in seawater retained their physical shape beyond the first week of leaching. All other specimens had crumbled during that period.

The five FitzPatrick waste-form specimens that were cured at ambient temperature were

leached in the same leachants used for the Brunswick Unit 1 specimens. The two FitzPatrick waste-form specimens that were baked for 4 h at 49°C during the first day of curing were leached in deionized water and synthetic Barnwell ground water with pH 4.2. Following the initial leaching period specified in the "Technical Position on Waste Form" (Revision 0), only the two specimens leached in deionized water were tested further. For the two samples leached in deionized water (i.e., one cured at ambient temperature and one that had been baked for 4 h), leachates were changed out three additional times after leaching intervals of 45, 28, and 76 days for a total of 247 days before long-term leaching was discontinued. It should be noted that all the FitzPatrick samples that were cured at ambient temperature retained their physical shape through the 90-day leaching period; however, both samples that were baked had crumbled by the end of the initial 90-day period.

Data Analysis. Leaching occurs as the result of mass transport of species both inside and from the surface of a waste form. Mass transport processes that have been identified as occurring in solidified waste forms during leaching include diffusion, dissolution, ion exchange, corrosion, and surface effects. A considerable amount of data that were obtained from samples that maintained their integrity during leaching indicate that internal bulk diffusion is the most likely rate-determining mechanism during the later phases of the leaching process.^{24,28,29} The methods used to assess leachability (i.e., fractional release, cumulative fractional release, and leachability index) are based on the premise that internal bulk diffusion is the rate-determining process and are predicated on an intact waste form. However, because some of the Brunswick Unit 1 and James A. FitzPatrick samples either partially or totally disintegrated during the ANSI/ANS 16.1 leach period, modifications were made to the methods used to determine the surface area of the disintegrated waste forms.

The method used to calculate the surface area of the disintegrated waste forms is based on the formation of a diffusion boundary between the

layer of particulate debris on the bottom of the leaching vessel and the leachant. During the early stages of waste form disintegration, when a large portion of the waste form was intact, the total surface area of the waste form was considered to be the sum of the exterior surface area of the partial waste form (typically 180–230 cm² for the intact waste form) plus the surface area of the bottom of the leaching vessel over which the debris was spread (about 165 cm²). As the waste forms continued to disintegrate, the surface area of the partial waste form decreased, but the surface area of the diffusion boundary on the bottom of the leaching vessel remained essentially constant ranging from 163 to 172 cm² depending on the shape of the walls of the leaching vessel. Consequently, the specimen surface areas ranged from about 220 cm² (with no degradation) to about 370 cm² (after waste-form degradation began) to about 165 cm² (after complete decomposition has occurred). This approach allowed the determination of the relative leachability of waste-form specimens leached in different leachants.

For each waste-form specimen that was leach-tested, the initial inventory of each specie in the waste form was determined by multiplying the measured concentration of the specie in the untreated wet resin waste, expressed as $\mu\text{Ci/g}$ or $\mu\text{g/g}$, times the mass of water-saturated resin estimated to be in the waste-form specimen. The quantity of resin estimated to be in the waste form is based on the weight fraction of water and resin present in the resin/cement mixture in the solidification liner from which the specimen was obtained. This method is considered relatively accurate as the waste-form samples were obtained from the interior of liners that had been well mixed before sample collection.

The second calculation to be performed is for the average absolute and fractional release rates of radionuclides, metals, and chelating agents from each waste-form specimen. The average absolute release rate is defined as the quantity released per unit surface area per second ($\mu\text{Ci/cm}^2\cdot\text{s}$ or $\mu\text{g/cm}^2\cdot\text{s}$), and the fractional release rate is defined as the fraction of the initial inventory released per unit surface area per

second (F/cm²·s). The surface area used in this calculation is normally predicated on the external surface area of an intact waste form; however, in the cases of the Brunswick Unit 1 and FitzPatrick samples, the methods previously discussed above were used to compensate for the fact that the samples disintegrated during leaching.

The ANSI/ANS 16.1 standard provides for the calculation of a leachability index, which is one of the measures used in the NRC's "Technical Position on Waste Form" (Revision 1) to determine the acceptability of a waste form for disposal at a waste site. The leachability index, L, is based on the effective diffusivity of the species being leached from the waste form. When depletion of the diffusant is less than 20% the effective diffusivity (D_n) is defined as

$$D_n = \pi [(a_n/A_0)/\Delta_n]^2 \times (V/S)^2 \times T \quad (1)$$

where

D_n = the effective diffusivity of a specie during leaching interval n (cm²/s)

a_n = the quantity of the species leached during leaching interval n (μCi or μg)

A₀ = the total amount of the species originally present in the waste-form specimen (μCi or μg)

Δ_n = the duration of leaching interval n (s)

V = the volume of the waste-form specimen (cm³)

S = the external geometric surface area of the waste-form specimen (cm²)

T = the leaching time representing the "mean time" of the nth leaching interval (s).

As shown in Equation (1), effective diffusivity is proportional to the square of the ratio of specimen volume to surface area.

Surface areas of specimens that disintegrated were calculated using the method previously described. The waste-form volumes used in Equation (1) for specimens that disintegrated were the volumes of the waste-forms prior to the initiation of leaching. The specimen volumes were kept constant for the purpose of calculating effective diffusivities because the total activity in the waste form, A₀, which is calculated as the product of specimen volume and diffusant concentration, remains constant independent of the physical state of the waste form.

The leachability index is based on the effective diffusivity of the species of interest, and is also dependant on the estimated surface area of the debris. The leachability index, L, is defined as

$$L = \frac{1}{k} \sum_{n=1}^k [\log(b/D)]_n \quad (2)$$

where

b = defined constant (1.0 cm²/s)

D = effective diffusivity of the species (cm²/s)

k = number of leaching intervals.

As shown in Equation (2), the leachability index of a particular diffusing species is the summation of the incremental leachability indexes for the all leach intervals.

As a sample disintegrates, the surface area of the sample increases by about a factor of two (as a maximum), and for a given species concentration in the leachate, the average release rate and the effective diffusivity would become smaller (about a factor of 4) as compared to their values for the intact waste form. Based on the assumptions made, the disintegration of the waste-form specimen would have only a minimal effect on the calculated leachability index. However, the

assumed surface of the disintegrated samples would provide a conservative estimate of the actual leachability for the potentially much larger surface area of the granular debris. This approach is consistent with the definition of specimen surface area as defined in ANSI/ANS 16.1, and because the same method was used for all specimens that crumbled, it allows the leachability for each specie in the waste-form specimens to be compared. It is also consistent with the leachability of the waste forms as discussed in the results section.

The cumulative fraction release (CFR) of radionuclides, metals, and chelating agents from the waste-form specimens is calculated as

$$CFR = \frac{\sum_{i=1}^n [(C_L)_n V_n]_i}{C_R M_R} \quad (3)$$

where

$(C_L)_n$ = the concentration of the species in the leachate collected following leaching interval n ($\mu\text{Ci/ml}$ or $\mu\text{g/ml}$)

V_n = the volume of leachate collected following leaching interval n (ml)

C_R = the concentration of the species in the resin waste ($\mu\text{Ci/g}$ or $\mu\text{g/g}$)

M_R = the mass of resin waste estimated to be in the waste form (g).

Uncertainties in the CFRs of selected radionuclides, metals, and citric, oxalic, and picolinic acids were calculated at the one-sigma confidence level using representative data for resin waste and leachate samples. Uncertainties in the absolute counting efficiencies of the hyperpure germanium (HPGe) spectrometers used to determine concentrations of gamma-emitting radionuclides were assumed to be $\pm 5\%$. The

uncertainty in the volume of any given leachate sample was assumed to be $\pm 1\%$, and the uncertainty in the mass of resin waste in any given waste-form specimen was assumed to be $\pm 5\%$.

Using the uncertainties previously given and the random errors associated with counting statistics, the uncertainties in the CFRs of the gamma-emitting radionuclides ^{54}Mn , ^{60}Co , and ^{137}Cs were estimated to be 60%, 20%, and 20%, respectively, after 10 leaching intervals. Similar results for the beta-emitters ^{55}Fe , ^{63}Ni , and ^{90}Sr were 42%, 48%, and 33%, respectively. The uncertainty in the concentration of iron in any given leachate sample was typically 33%, resulting in an uncertainty of about 100% in the CFR of iron after ten leaching intervals. Uncertainties in the concentrations of citric and oxalic acids were typically about 50% and 70%, respectively, due to uncertainties associated with the chemical separation performed, resulting in uncertainties of about 150% and 200% in the CFRs of citric and oxalic acids, respectively, after 10 leaching intervals. Uncertainties in the concentrations of picolinic acid were typically 10%, so uncertainties in CFRs of picolinic acid were about 34% after 10 leaching intervals. Consequently, the uncertainties in the CFRs for the species measured are often relatively large. In the results section, the effects of these uncertainties on the measured CFRs are discussed.

Compressive Strength Test Method

The test procedure used to measure the compressive strength of waste-form specimens was ASTM C39, "Compressive Strength of Cylindrical Concrete Specimens" (see Reference 3), as recommended by the NRC in the "Technical Position on Waste Form," which requires a minimum compressive strength for waste forms of 50 psi (3.4×10^2 kPa). This requirement has been modified in Appendix A of the "Technical Position on Waste Form" (Revision 1) to 500 psi (3.4×10^3 kPa) for cement-solidified waste forms. The revised higher value is deemed necessary to ensure that cement-solidified waste forms

maintain integrity and exhibit long-term stability as required by 10 CFR 61.

An example of a waste-form specimen prior to compressive strength testing is shown in Figure 5. As shown in the figure, epoxy end-caps were added to each specimen to provide ends that were planar and perpendicular to the longitudinal axis of the specimen. The vice and load gauge used to measure compressive strength are shown in Figure 6. Each specimen was placed in the vice, and the load on the specimen was gradually increased until the load gauge registered a decrease in load, which occurred when the specimen began to fail. The maximum load that each waste-form specimen withstood was recorded and was used to compute the compressive strength of the specimen based on its cross-sectional area.

Because the Brunswick Unit 1 and FitzPatrick waste-form specimens that were leach-tested had cracked or crumbled, only specimens that had been archived were tested for compressive strength. One cation and one mixed-bed resin waste-form specimen obtained from Brunswick Unit 1 were tested. At the time they were subjected to compressive strength testing, they had been cured a total of 486 days. Two waste-form specimens collected from James A. FitzPatrick Station were also tested (cure time = 212 days). One specimen had been baked for 4 h at 49°C during initial curing, and the second had been cured at ambient temperature. In all cases, the measured compressive strength as discussed in the results section substantially exceeded the requirements in the NRC's "Technical Position on Waste Form" (Revision 0); however, several samples did not meet the new requirement of 500 psi.

In addition to the four waste-form specimens from the current study that were compression tested, four waste-form specimens obtained from Pilgrim Station and Indian Point-3 Station during a previous study¹² were also subjected to compressive strength testing. Summary results for all compression tests are shown in the results section.

Analytical Methods

The data analysis methods of ANSI/ANS 16.1 require a knowledge of the initial inventories of diffusing species in the waste-form sample being tested and a knowledge of their concentrations in the leachates generated during leach testing. In order to provide a basis for estimating the initial inventories of species of interest, samples of unsolidified resin waste and leachate samples were analyzed using several different analytical techniques. Because of the differences in their physical characteristics and because the concentrations of radionuclides and metals in the leachates were expected to be as much as several orders of magnitude lower in the leachates compared to the resins, the methods required to prepare the resin and leachate samples for analysis were generally quite different.

Prior to analysis, leachate solutions were partitioned into volumetric samples according to the

Figure 5. Waste-form specimen with epoxy end-caps prior to testing for compressive strength.

Figure 6. Compressive strength testing system.

analysis scheme shown in Figure 7. As shown in Figure 7, the analytical methods used to determine concentrations of radionuclides, transition metals, and chelating agents in leachate samples included high-resolution gamma ray spectrometry, liquid scintillation and gas proportional counting, inductively coupled plasma-atomic emission spectroscopy, and ion chromatography (IC). The detection of chelating agents in some leachate solutions required that the chelating agent be chemically separated from other components of the sample prior to IC analysis.

The following sections provide descriptions of the sample preparation and analysis methods used to analyze the resin waste and leachate samples obtained during the course of this study.

Radionuclide Analysis. Resin waste samples were analyzed for radionuclides specified in 10 CFR 61 (e.g., ^{54}Mn , ^{60}Co , ^{63}Ni , ^{90}Sr , ^{137}Cs , ^{238}Pu , ^{239}Pu , ^{241}Am , ^{242}Cm , and ^{244}Cm) using standard environmental analysis procedures.³⁰ In each case, two samples of resin were removed

from the resin waste after it had been homogenized using a stirrer set at low speed. The vials containing the extracted resin samples were vibrated until the resin beads had completely settled into the bottoms of the vials. All free-standing water was then removed from the vials, and the volumes and masses of the water-saturated resin samples were recorded.

The duplicate resin samples analyzed for concentrations of beta- and gamma-emitters were wet-ashed using fuming sulfuric acid. The solutions were then distilled to dryness and dissolved in 4 M HCl.

Concentrations of gamma-emitting radionuclides in each resin sample were determined by diluting an aliquot of the acid solution with water and analyzing this volumetric sample using gamma spectrometric techniques. The HPGe spectrometers used to analyze these samples were calibrated using reference sources traceable to the National Institute of Standards and Testing (NIST).

Figure 7. Leachate solution analysis scheme.

Concentrations of beta emitters (e.g., ⁵⁵Fe, ⁶³Ni, ⁹⁰Sr, and ²⁴¹Pu) in the resin wastes were determined using radiochemical separation techniques followed by liquid scintillation and gas proportional counting.

Stable iron, nickel, and strontium carriers and ⁸⁵Sr tracer were added to an aliquot of the dissolved resin waste, and the solution was then passed through a chloride-form anion exchange column. Iron in the solution was left on the

column while nickel and strontium passed through it. Unwanted radionuclides were washed from the column using HCl and HF acids, and the iron was then eluted using 0.5 M HCl. Ammonia and iron were added to the eluent of the column, and this alkaline solution was treated with dimethylglyoxime to selectively extract nickel, and sulfate was added to another aliquot to precipitate strontium as strontium sulfate. More detailed descriptions of the radiochemical separation procedures are provided in Reference 30. Concentrations of ^{55}Fe and ^{63}Ni were determined by analyzing the separated activities using a liquid scintillation counter, and the concentration of ^{90}Sr was determined using a gas proportional counter.

The duplicate resin samples analyzed for concentrations of transuranic (TRU) isotopes were wet-ashed using nitric, sulfuric, and perchloric acids. This procedure was followed by a pyrosulfate fusion to dissolve any remaining undissolved compounds. The fusion was then dissolved in acidic water, and the actinides were precipitated using barium sulfate. The barium sulfate precipitate was then dissolved in alkaline EDTA to precipitate the actinides as hydroxides. The hydroxide precipitate was then dissolved in acid, and then the solution was oxidized to adjust the oxidation state of plutonium. Americium and curium were precipitated as fluorides and, following filtration, this precipitate was mounted for analysis using a high-resolution alpha spectrometer. The filtrate was reduced, and plutonium was precipitated as plutonium fluoride. The plutonium fraction was also analyzed using a high-resolution alpha spectrometer.

Average concentrations of radionuclides and TRU isotopes in the Brunswick Unit 1 and FitzPatrick resin waste samples were computed as averages of the results for two duplicate samples.

As shown in Figure 7, the concentrations of gamma-emitting radionuclides (e.g., ^{54}Mn , ^{58}Co , ^{60}Co , ^{65}Zn , ^{125}Sb , ^{134}Cs , and ^{137}Cs) in leachates were determined using HPGe spectrometers. In each case, a 540 ml sample of leachate was col-

lected after the leachate had been gently stirred using a stirring rod. Because the waste-form specimens obtained from Brunswick Unit 1 began to crumble during the initial leachings, all of the Brunswick Unit 1 waste-form leachates were filtered through 0.45 μm filters, and the filters and filtrates were analyzed separately using HPGe spectrometers. In the case of the FitzPatrick waste-form specimens, leachates generated during the first 98 days of leaching were not filtered prior to analysis. However, because the FitzPatrick waste-form specimens leached in deionized water continued to deteriorate, leachates collected between 98 and 247 days were filtered through 0.45 μm filters prior to analysis.

Concentrations of ^{55}Fe , ^{63}Ni , and ^{90}Sr in leachate samples were determined by first using radiochemical techniques to selectively extract and concentrate these radionuclides. Carriers and tracers were added to volumetric samples of the leachates, and the samples were then evaporated to dryness. The samples were then dissolved in HCl acid, and these dissolutions were processed and analyzed using the same procedures used to process and analyze the resin-waste samples. Because of the high concentrations of chemical compounds in the leachate samples, the extraction and purification of the beta-emitters proved to be quite tedious and time consuming. In the case of seawater leachates, the quantity of precipitate generated from each leachate sample was so large that it made the method impractical. Consequently, concentrations of ^{55}Fe , ^{63}Ni , and ^{90}Sr were determined for only selected seawater leachate samples.

Because time-consuming radiochemical separations were required to determine the concentrations of ^{55}Fe , ^{63}Ni , and ^{90}Sr , only a limited number of leachate samples were analyzed for these beta-emitting radionuclides. In the case of the Brunswick Unit 1 waste-form specimens, five of the first ten leachate samples for each waste-form specimen were analyzed for these three beta emitters. Normally, every other leachate sample was analyzed. In the case of the FitzPatrick waste forms, leachate samples were

analyzed for ^{55}Fe and ^{63}Ni . None of the FitzPatrick waste-form leachates were analyzed for ^{90}Sr .

^{241}Pu analyses were performed on leachate samples from the third leach period, which was expected to have the highest concentration of transuranics. Because the measured concentrations were near the detection limit for the analysis technique, no further analyses were performed.

Elemental Analysis. Samples of dissolved resin wastes and leachate solutions were analyzed using atomic absorption spectroscopy (AA) and inductively coupled plasma-atomic emission spectroscopy (ICP-AES), respectively. All samples were analyzed for concentrations of chromium, iron, cobalt, and nickel. These elements were selected for analysis because they are the primary constituents of stainless steel and Inconel, the materials used to line the internal surfaces of LWR primary coolant systems. Analysis procedures for the resin samples included optimizing the atomic absorption spectrometer's optics by focusing on a strong transition metal solution, aligning the aperture plate based on the mercury line position, and calculating metal concentrations using four-point calibration curves. Leachate samples were analyzed using ICP-AES through similar calibrations, although more than one elemental analysis can be performed at a time using this technique. Potential analytical background interferences introduced by high concentrations of Ca^{+2} and other ions were evaluated using prepared standards. Only lot-analyzed, trace metal analysis grade reagents were used to prepare standards.

Chelating Agent Analysis. The concentrations of oxalic and citric acids and sulfate in the leachate samples resulting from the leach testing of the Brunswick Unit 1 AP/Citrox waste-form specimens were determined by ion chromatography (IC) using a Dionex HPIC AS5A-51 separator column and Dionex conductivity detector. Figure 8 is a representative chromatogram for a leachate sample containing oxalic acid, citric acid, and sulfate. The IC system used to perform the measurements was equipped with a Dionex ATC-1 carbonate trap and a Dionex HPIC AG5A

guard column. Chromatograms were recorded using a Dionex 4270 programmable integrator. An eluent gradient was employed, which ramped from 16 mM NaOH to 100 mM NaOH over 15 minutes. Eluent strength was maintained at 100 mM NaOH for 5 minutes following the ramp. Eluent flow was maintained at 1 mL/minute at a system pressure of about 2300 psig. Four-point calibrations were performed using standardized solutions of the five different leachants.

Each Brunswick Unit 1 waste-form leachate sample was initially passed through a column packed with AG MP-50, 50-100 mesh hydrogen-form cation resin to remove cationic radionuclides such as ^{60}Co . Because the retention times of sulfate and oxalic acid were close to one another, leachates having high concentrations of sulfate were treated with BaCl_2 prior to analysis to precipitate the sulfate as BaSO_4 . The simulated Hanford ground water leachates and the simulated seawater leachates contained high concentrations of sulfate and were, therefore, treated with BaCl_2 before they were subjected to IC analysis. Because the simulated seawater leachates contained high concentrations of Cl^- ,

Figure 8. Chromatogram showing oxalic acid, citric acid, and sulfate in a Brunswick Unit 1 sample.

they were passed through Dionex OnGuard-Ag pretreatment cartridges in order to selectively remove the Cl^- . The cation resin waste-form leachate samples were not analyzed for citric and oxalic acids as the concentrations of these chelating agents would be expected to be low because the anionic ligand of these acids would not be expected to be highly concentrated on this resin.

The leachate samples resulting from the leach testing of the James A. FitzPatrick LOMI/NP/LOMI waste-form specimens were analyzed for picolinic acid using IC methods. Figure 9 shows a representative chromatogram for this chelating agent. Picolinic acid has a distinctive absorption spectrum in the ultra violet (UV) region with peaks at 264, 267, 271, and 275 nm. The concentration of picolinic acid can, therefore, be determined by direct measurement. Picolinic acid was separated from other ionic species using two Dionex HPIC-AG3 columns connected in series and was detected using a Dionex variable wavelength detector set at an absorbance wavelength of 264 nm. The eluent used was 0.01 M sodium perchlorate (neutral pH) at a flow rate of 1.0 ml/minute. Five-point calibrations were performed using standardized solutions of picolinic acid in the five different leachants. The calibration data indicated the response of the UV detector was non-linear above about 5 ppm, so the calibration data were fit with quadratic functions using least squares methods.

As was the case with the Brunswick Unit 1 waste-form leachates, the FitzPatrick waste-form leachates were initially passed through columns packed with AG MP-50, 50-100 mesh hydrogen-form cation resin to remove cationic radionuclides. Standard solutions of picolinic acid were prepared using the five leachants, and they were passed through columns of the

AG MP-50 cation resin to determine the retention efficiency of the columns for picolinic acid. Measured concentrations of picolinic acid in leachates were corrected for losses of picolinic acid in the cation columns.

Figure 9. Chromatogram showing picolinic acid in a James A. FitzPatrick sample.

EXPERIMENTAL RESULTS

A primary objective of this leach study was to evaluate the effects of leachant chemical composition and pH on the release, effective diffusivity, and leachability of species from solidified decontamination resin waste forms. These effects are evaluated for radionuclides, chelating agents, and stable metals found in the decontamination resin waste forms using the models discussed in the previous section. Leaching data are shown graphically as plots of cumulative fractional release versus the square root of elapsed leaching time. This presentation was chosen to facilitate evaluation of the data since the plots will be linear if diffusion is the controlling release mechanism and will have slopes that are proportional to the corresponding effective diffusivities. The leaching results are given in tabular form for each radionuclide, chelating agent, and stable metal. The release rates for these species are tabulated as quantity released per unit surface area per second ($\mu\text{Ci}/\text{cm}^2\cdot\text{s}$ or $\mu\text{g}/\text{cm}^2\cdot\text{s}$) and as fraction of initial inventory released per unit surface area per second ($\text{F}/\text{cm}^2\cdot\text{s}$) as defined previously. Fractional release rates of selected radionuclides and chelating agents are plotted versus the square root of leaching time.

The experimental results presented in the following sections include discussion of (a) concentrations of radionuclides, metals, and chelating agents in the Brunswick Unit 1 and FitzPatrick resin wastes, (b) leach-test results for five cation and five mixed-bed resin waste-form specimens

from Brunswick Unit 1, (c) leach-test results for seven FitzPatrick mixed-bed resin waste-form specimens, and (d) compressive strengths of waste-form specimens collected from Brunswick Unit 1, FitzPatrick, Pilgrim, and Indian Point-3 Stations. The photographs and data on which these discussions are based are presented both in the body of the report and in Appendices B through K. A comparison of the leachability of the waste forms in different leachants is presented in the discussion section.

Concentrations of Radionuclides, Stable Metals, and Chelating Agents in Resin Wastes

The concentrations of radionuclides, stable metals, and chelating agents in the resin waste samples obtained from Brunswick Unit 1 and FitzPatrick were measured in order to determine the quantities of these species present in the solidified waste-form specimens prior to the initiation of leach testing. The radionuclide, stable metal, and chelating agent concentrations measured for the resins were converted to the inventories present in the waste forms using the waste concentrations in the liner as was discussed in the previous section.

The concentrations of radionuclides, chelating agents, and stable metals in the resin wastes are presented in Table 6 as $\mu\text{Ci}/\text{g}$ for radionuclides or

Table 6. Concentrations of radionuclides and stable metals in ion-exchange resin wastes^a

Nuclide	Brunswick Unit 1		
	($\mu\text{Ci}/\text{g}$)		
	Cation	Mixed-Bed	FitzPatrick
⁵¹ Cr	— ^b	— ^b	4.3 ± 0.5 (–1)
⁵⁴ Mn	5.30 ± 0.03 (–1)	2.19 ± 0.01 (–2)	1.25 ± 0.01 (+0)
⁵⁵ Fe	2.8 ± 0.2 (+0)	1.5 ± 0.1 (–1)	6.80 ± 0.09 (–2)
⁵⁹ Fe	<6.3 (–2)	<1.1 (–2)	4.70 ± 0.03 (–1)
⁵⁷ Co	— ^b	— ^b	5.2 ± 0.2 (–3)

Table 6. (continued)

Nuclide	Brunswick Unit 1		
	(μCi/g)		
	Cation	Mixed-Bed	FitzPatrick
⁵⁸ Co	5.5 ± 0.7 (-2)	2.9 ± 0.5 (-3)	1.30 ± 0.01 (+0)
⁶⁰ Co	2.65 ± 0.03 (+0)	1.35 ± 0.01 (-1)	4.91 ± 0.01 (+0)
⁶³ Ni	5.16 ± 0.2 (-1)	4.25 ± 0.23 (-2)	1.68 ± 0.09 (-1)
⁶⁵ Zn	3.5 ± 0.6 (-2)	2.0 ± 0.4 (-3)	2.92 ± 0.08 (-1)
⁹⁰ Sr	1.44 ± 0.09 (-3)	8.1 ± 0.5 (-4)	7.6 ± 0.6 (-5)
⁹⁵ Zr	<1.5 (-2)	<5.2 (-3)	6.4 ± 0.6 (-3)
⁹⁵ Nb	— ^b	— ^b	1.4 ± 0.1 (-2)
¹¹³ Sn	— ^b	— ^b	7.2 ± 0.7 (-3)
¹²⁵ Sb	1.3 ± 0.2 (-3)	5.19 ± 0.03 (-3)	1.07 ± 0.07 (-2)
¹³⁴ Cs	<3.2 (-4)	<7.2 (-5)	9.6 ± 0.3 (-3)
¹³⁷ Cs	1.40 ± 0.02 (-2)	3.7 ± 0.1 (-4)	1.96 ± 0.05 (-2)
²³⁸ Pu ^c	2.6 ± 0.2 (-7)	7.9 ± 0.6 (-8)	2.50 ± 0.06 (-5)
²³⁹ Pu	2.0 ± 0.1 (-7)	6.9 ± 0.6 (-8)	4.48 ± 0.08 (-5)
²⁴⁴ Pu	2.1 ± 0.2 (-3)	2.1 ± 0.2 (-3)	6.7 ± 0.5 (-2)
²⁴¹ Am	— ^c	— ^c	3.74 ± 0.07 (-5)
²⁴² Cm	-1.2 ± 2.0 (-8)	3 ± 2 (-8)	4.12 ± 0.08 (-5)
²⁴⁴ Cm	2.6 ± 0.5 (-8)	5 ± 3 (-9)	4.3 ± 0.1 (-6)
<u>Stable Metals</u>			
Chromium	4.5 ± 0.2 (+2)	1.58 ± 0.06 (+3)	1.95 ± 0.07 (+2)
Iron	6.4 ± 0.2 (+3)	6.9 ± 0.1 (+2)	2.38 ± 0.05 (+3)
Cobalt	2.08 ± 0.06 (+2)	2.97 ± 0.06 (+2)	2.56 ± 0.06 (+2)
Nickel	7.3 ± 0.3 (+2)	6.4 ± 1.4 (+1)	1.16 ± 0.04 (+2)
<u>Chelating Agents</u>			
Oxalic acid	— ^d	2.0E + 4 ^e	— ^d
Citric acid	— ^d	4.1E + 4 ^e	— ^d
Picolinic acid	— ^d	— ^d	1.0E + 4 ^e

a. The measured concentrations are the weighted averages of the results for duplicate samples with one-sigma uncertainties. Counting uncertainties are reported for the gamma ray emitters whereas the uncertainties for stable metals, beta emitters (⁵⁵Fe, ⁶³Ni, ⁹⁰Sr), TRU isotopes, and chelating agents reflect both random and systematic errors. Radionuclide concentrations are decay-corrected to the sample collection dates—December 18, 1987 for Brunswick Unit 1 and September 18, 1988 for James A. FitzPatrick.

b. Not detected.

c. The measured concentration of ²³⁸Pu is the total concentration of ²³⁸Pu and ²⁴¹Am for the Brunswick Unit 1 samples.

d. Not measured.

e. Vendor supplied concentrations with the exception of picolinic acid where the data indicated that the actual concentration was at least 2.2E + 4 μg/g.

μg/g of stable metals or chelates in the water-saturated resin. The dates to which all radionuclide concentrations were decay-corrected for each plant are listed in the table.

The summed radionuclide concentrations in the Brunswick Unit 1 cation resin waste was 6.68 μCi/g resin in contrast to the mixed-bed resin waste, which contained only a total of 0.38 μCi/g resin. The major activities in the Brunswick-1 resins were ⁵⁴Mn, ⁵⁵Fe, ⁶⁰Co, and ⁶³Ni, which constituted greater than 90% of the total activity in the cation and mixed-bed resin wastes, respectively. The dominant radionuclides, ⁶⁰Co and ⁵⁵Fe, made up about 40% and 42% of the total activity in the cation resin waste, respectively, and 36% and 39% of the total activity in the mixed-bed resin waste. In contrast, the measured fission products, ⁹⁰Sr and ¹³⁷Cs combined, constituted about 0.2% of the total activity in the cation resin and 0.3% of the total activity in the mixed-bed resin waste.

The summed radionuclide concentrations in the FitzPatrick mixed-bed resin waste was higher than the Brunswick-1 resin at 9.0 μCi/g, with ⁵¹Cr, ⁵⁴Mn, ⁵⁹Fe, ⁵⁸Co, ⁶⁰Co, and ⁶⁵Zn being the major activities. Their combined activities constituted about 96% of the total activity. Cobalt-60 was the dominant activity, making up 54% of the total activity in the resin waste. As was the case with the Brunswick Unit 1 resin wastes, the activities of the fission products ⁹⁰Sr and ¹³⁷Cs were very low; combined, they made up only 0.2% of the total activity in the FitzPatrick resin waste.

The concentrations of the transuranic isotopes in the Brunswick-1 resins summed to a total of 2.1×10^{-3} μCi/g for both the cation and mixed-bed resins. In contrast, the total concentration of TRU isotopes in the FitzPatrick resin waste was about three orders of magnitude higher with a summed concentration of 6.7×10^{-2} μCi/g. In all cases, greater than 90% of the activity was ²⁴¹Pu.

Among the stable metals whose concentrations were measured in the resin wastes, the iron concentration was highest in the cation resin waste obtained from Brunswick Unit 1 at 0.6 wt.% and

the mixed-bed resin waste obtained from James A. FitzPatrick Station at 0.2 wt.%. In contrast, chromium had the highest concentration (about 0.2 wt.%) in the mixed-bed resin waste obtained from Brunswick Unit 1.

The concentrations of citric and oxalic acids in the mixed-bed resin waste obtained from Brunswick Unit 1 were reported by the decontamination vendor to be 4.1 wt.% and 2.0 wt.%, respectively, and the concentration of picolinic acid in the resin waste collected from James A. FitzPatrick Station was reported to be 1.0 wt.%. The vendor-supplied concentrations, for the chelating agents, as shown in Table 6 were used for calculational purposes; however, as will be discussed, the cumulative release data for the FitzPatrick waste-form specimens indicated that the actual concentration of picolinic acid in the waste-form sample tested was probably at least 2.2 wt.% in contrast to the vendor-supplied concentrations of 1.0 wt.%. The concentrations of citric and oxalic acids in the Brunswick-1 resin wastes and leachates were not measured because the anionic ligand is not expected to be concentrated in significant amounts on the cationic resin. Consequently, a 2.2 wt.% inventory of picolinic acid was used for calculational purposes.

Leach-Test Results for Brunswick Plant Unit 1 Waste-Form Specimens

This section presents the results of leach tests performed on five cation and five mixed-bed resin waste-form specimens collected from Brunswick Unit 1. The following results are discussed for the two waste form types: (a) the physical stability of waste-form specimens during leaching, (b) the final pH and conductivity of leachates, (c) the effects of different leachates on the cumulative fraction releases, incremental fraction release rates, and leachability indexes of radionuclides, chelating agents and stable metals, and (d) long-term leaching results.

Physical Stability of Waste-Form Specimens During Leaching. The physical stability of the waste-form specimens from Brunswick-1

varied significantly. Many of the specimens deteriorated within several hours. Table 7 summarizes the degradation of each waste-form sample during leaching.

Examination of Table 7 indicates that the only waste-form specimen that maintained their gross physical shape during leaching were those samples leached in seawater; however, they had probably lost their compressive strength very early in the leaching program as indicated by the fact that the cation resin sample leached in seawater split into two parts after 10 hours. Examination of these results suggest that although the pH of the solution was not a factor in maintaining the shape of the sample, the composition and high ionic

strength of the seawater leachant may have prevented the samples from decomposing.

Only the cation and mixed-bed resin waste-form specimens leached in synthetic seawater maintained their gross physical shapes through the prescribed 90 days of leaching. As indicated in Figure 10, stalagmites grew from cracks on the upper surface of the cation specimen, and after 24 h, these growths were about 5 cm long. The photograph shows the stalagmites and the radial cracks that appeared on the surface of one end of the specimen during the first 2-h leaching interval.

Figure 11 is a photograph of the cation resin waste-form specimen after 90 days of leaching. The striations on the surface of the waste-form

Table 7. Physical deterioration of the Brunswick Unit 1 samples

Waste Form	<1 Hour	8 Hours	>8 Hours	90 days
Cation Resin				
Deionized water	—	Cracking	Decomposed ^a	Rubble
Seawater (pH 6.4)	—	Cracking	Two pieces ^{a,b}	Maintained shape
Hanford (pH 8.9)	—	Cracking ^c	Decomposed ^a	Rubble
Barnwell (pH 4.2)	—	Cracking ^c	Decomposed ^a	Rubble
Barnwell (pH 10.4)	—	Cracking ^c	Decomposed ^a	Rubble
Mixed-Bed Resin				
Deionized water	Decomposed ^d	—	Rubble ^a	Rubble
Seawater (pH 6.4)	—	—	—	Maintained shape
Hanford (pH 8.9)	Decomposed ^d	—	Rubble ^a	Rubble
Barnwell (pH 4.2)	Decomposed ^d	—	Rubble ^a	Rubble
Barnwell (pH 10.4)	Decomposed ^d	—	Rubble ^a	Rubble

a. Within 1 week, all identified samples had decomposed to granular rubble.

b. The cation resin waste form split into two pieces after 10 hours with no further decomposition through the entire 90 days.

c. In addition to cracks covering the surface of the waste form, between 3% and 15% of each sample had sloughed off and dropped to the bottom of the leaching vessel.

d. Effervescence and crumbling began within minutes of placing the waste form in the leachant, and 20–30% of the original volume of the sample sloughed and dropped to the bottom of the container within 8 hours.

Figure 10. Brunswick Unit 1 cation resin waste-form specimen leaching in synthetic seawater during the first 2-h interval.

Figure 11. Brunswick Unit 1 cation resin waste-form specimen after leaching in synthetic seawater for 90 days.

specimen are the result of the specimen support netting pressing against the surface of the specimen and, thereby, preventing material from being deposited on the surface at those locations. The waste-form specimen is coated with a light grey material.

The mixed-bed resin waste-form specimen leached in synthetic seawater also cracked during the first 24 h of leaching as shown in Figure 12. A stalactite grew from a crack on the lower surface of the sample. The photograph shows the stalactite and the relatively heavy coating of material that covered the surface of the specimen. Figure 13 is a photograph of the same specimen after the completion of 90 days of leaching in synthetic seawater. Comparing Figures 11 and 13, it is evident that the material coating the surface of the mixed-bed resin waste-form specimen

was substantially thicker than that covering the surface of the cation resin waste-form specimen.

Figure 14 shows a mixed-bed resin waste-form specimen beginning to crumble during the first hour of leaching in synthetic Barnwell ground water. Large grains can be seen, which had sloughed off one end of the specimen. This rapid deterioration was typical of the behavior of the majority of the Brunswick-1 waste-form specimens, the exceptions being the two specimens leached in seawater. Figure 15 shows a cation resin waste-form specimen after leaching in deionized water for 239 days. The condition of the specimen shown in Figure 15 is representative of the extent of deterioration observed for all but the two specimens leached in synthetic seawater.

Other photographs that provide graphic histories of the behavior of the Brunswick Unit 1 cation resin waste-form specimens during leaching are shown in Appendix B; those describing the Brunswick Unit 1 mixed-bed waste-form specimens are presented in Appendix C; and for comparison purposes, those showing the behavior of the FitzPatrick mixed-bed waste-form specimens are included in Appendix D.

Results of Brunswick-1 Cation Resin Waste-Form Specimens. The following sections discuss the leach test results of Brunswick-1 cation resin waste-form specimens. The results discussed include leachate final pH and conductivity, the releases of radionuclides, chelating agents and stable metals from the waste forms at 90 days, the effects of different leachants on the releases of radionuclides, chelating agents, and stable metals, and a summary of the long-term leaching behavior.

Brunswick-1 Cation Resin Leachate pH and Conductivity. To assess the effects of pH and conductivity on the leachability of the waste-form specimens, pH and conductivity measurements were made on the Brunswick-1 cation resin leach solutions at the end of each leaching period to determine the effects of the waste form on the leachant chemistry. The pH and conductivities for each leaching interval are plotted in

Figure 12. Brunswick Unit 1 mixed-bed resin waste-form specimen leaching in synthetic seawater during the first 2-h interval.

Figures 16 and 17, respectively. The waste-form leachates are identified in the figure legends as Barnwell ground water pH 10.4 (BGW pH 10.4), deionized water pH 7.0 (DW), Hanford ground water pH 8.9 (HGW), Barnwell ground water pH 4.2 (BGW pH 4.2), and seawater (SW).

As shown in Figure 16, the final pH of leachates other than seawater were comparable throughout the leach tests. At the end of the initial 2-h leaching interval, the pH of the leachates other than seawater ranged from 11.4 to 11.7. During the first three days of leaching, when leachates were changed out after elapsed times of 2, 7, 24, 48, and 72 h, the final pH of these

four leachates gradually increased, reaching maxima that ranged between 12.1 and 12.5. They then declined slightly during the subsequent two leaching intervals but remained in the general range from 11.8 to 12.3 through the remainder of the leaching program. In the case of the seawater leachant, leachate pH increased from 9.2 after the initial 2-h leaching interval to a maximum of 9.7 after 46 days of leaching.

The leachate pH data indicate that the initial pH of the leachant is affected within hours and probably minutes by the chemistry of the waste form. The pH of resin waste, which normally ranges between 3 and 4, is adjusted to about

Figure 13. Brunswick Unit 1 mixed-bed resin waste-form specimen after leaching in synthetic seawater for 90 days.

pH 11 prior to the solidification, and it appears that the relatively large quantities of calcium hydroxide in the waste-form specimen strongly affect the pH of the leachant except in the case of the seawater. The seawater has a very high ion strength due to the presence of large amounts of $\text{MgCl}_2 \cdot \text{H}_2\text{O}$ (14 g/L) and Na_2SO_4 (4.1 g/L). These compounds appear to have buffered the concentration of the leachate to a pH of 9.2 through 9.7 throughout the leach testing period. The fact that the pH remained relatively constant during the longer leaching periods (≥ 46 days) suggests that an equilibrium was established between the waste-form specimen and the leachant, which prevented changes in the pH of the solution and reduced the leachability of other species during the longer leach periods. Possible mechanisms for the buffering action of the seawater leachant and the formation of an equilibrium between the leachant and waste-form chemistry are evaluated in the discussion section.

Leachate conductivities shown in Figure 17 (expressed as mmho/cm at 25°C) were measured

Figure 14. Brunswick Unit 1 mixed-bed resin waste-form specimen during first hour of leaching in synthetic Barnwell ground water.

Figure 15. Brunswick Unit 1 cation resin waste-form specimen after leaching in deionized water for 239 days.

Figure 16. Leachate pH for five Brunswick Unit 1 cation resin waste-form specimens.

Figure 17. Leachate conductivity for four Brunswick Unit 1 cation resin waste-form specimens.

at the same time pH measurements were made at the end of each leach period. Conductivity is a measure of the quantity of ions that are present in a solution and that are capable of transferring an electrical charge. The four leachates other than seawater have very similar conductivities throughout the measurement period. The conductivities ranged from 0.8 to 1.4 mmho/cm after the initial 2 h of leaching. They then rose to maxima ranging between 4.1 and 4.7 mmho/cm after 3 days, and between 4 and 5 days, they decreased to minima ranging between 1.7 and 3.1 mmho/cm. The reason for this sudden increase in conductivity is not known but is assessed further in the discussion section.

Between 5 and 170 days, leachate conductivities rose to maxima between 4.4 and 5.3 mmho/cm; then the conductivities dropped significantly during the twelfth leaching period to between 2.1 and 3.2 mmho/cm. These data suggest that, at least initially, there were few ions present in the solution, but that the ion strength eventually went up to approximately 5.0 mmho/cm. As discussed in the discussion section, the reasons for the changes in conductivity are not known, but they do follow the general trend of the pH data, which indicate that the highly basic leachates contained quantities of anions that remained in the solution.

The conductivity of the seawater leachate samples was higher than the high range of the conductivity meter used, which was 20 mmho/cm. The high conductivities of the seawater leachates indicate that the solution was highly anionic during the leaching test. Because the seawater leachants were above the upper limit of available instruments, the conductivities for these leachants were not plotted in Figure 17.

Releases of Radionuclides, Chelating Agents, and Stable Metals from Brunswick-1 Cation Resin Waste-Form Specimens. This section presents the leaching results for the Brunswick-1 cation waste-form specimens. The results are presented as cumulative fractional releases, average release rates, and leachability indexes for the five samples that were leached. The radionuclide and stable metal leaching concentrations on which these values

are based are shown in Appendix J, Tables J1 through J5 and in other appendices identified there. It should be noted that only a limited number of leachate samples for the first ten leaching periods were analyzed for ^{55}Fe , ^{63}Ni , and ^{90}Sr , and the cumulative fractional releases (CFRs), average release rates, and leachability indexes were calculated based on interpolations between measured values. Due to the high concentration of ionic constituents in the seawater leachant, the results of ^{55}Fe and ^{63}Ni analyses were difficult to reproduce and resulted in large uncertainties in the data. Therefore, the Brunswick-1 seawater leachates were not analyzed for these three radionuclides.

Tables 8-12 show the CFRs average release rates, effective diffusivities, and the leachability indexes for the radionuclides and metals leached from the Brunswick-1 cation waste-form specimens for each of the five leachants used in accordance with the 90-day leaching period as required in the Branch Technical Position (BTP) on Waste Form (Revision 1).² Values for chelating agents, oxalic acid, and citric acid are not reported because they would not be expected to be concentrated on a cation resin; consequently, the cation resin waste-form samples were not analyzed for those chelating agents.

The concentrations of the stable metals leached from the Brunswick-1 cation resin waste-form specimen were below the detection limits for the analysis technique. Therefore, detection limit values were used to calculate the CFRs, release rates, and leachability indexes for all elements except iron. The measured and detection-limit results indicate that the leachability indexes for all stable metals were well above the BTP standard.

Table 8 presents the summary of the CFRs, release rates, and the leachability indexes for the Brunswick-1 cation resin waste-form specimen leached in deionized water for 90 days. Examination of the data indicates that the highest measurable CFRs for the radionuclides measured were those for ^{63}Ni , ^{90}Sr , and ^{137}Cs . Of these radionuclides, only ^{63}Ni was produced by neutron activation of the metal and released via the

Table 8. Leach test results for Brunswick Unit 1 cation resin waste-form specimen leached in deionized water^a

Nuclide	CFR	Release Rate		Average Effective Diffusivity (cm ² /s)	Leachability Index
		($\mu\text{Ci}/\text{cm}^2\cdot\text{s}$)	(F/cm ² ·s) ^b		
⁵⁴ Mn	1.2 (-4)	6 ± 2 (-11)	6 ± 2 (-13)	2 ± 1 (-14)	15.0 ± 0.5
⁵⁵ Fe	2.6 (-4) ^c	1 ± 1 (-9)	3 ± 3 (-12)	1 ± 1 (-13)	16 ± 1
⁵⁸ Co	<3.0 (-3)	<2.2 (-10)	<2.1 (-11)	<6.5 (-12)	>11.8
⁶⁰ Co	8.5 (-5)	1.9 ± 0.5 (-10)	4 ± 1 (-13)	1.0 ± 0.5 (-14)	15.3 ± 0.5
⁶³ Ni	3.5 (-4) ^c	9 ± 5 (-11)	9 ± 5 (-13)	5 ± 4 (-14)	14.5 ± 0.7
⁶⁵ Zn	<4.5 (-4)	<2.1 (-11)	<3.2 (-12)	<1.3 (-13)	>13.4
⁹⁰ Sr	6.5 (-2) ^c	3 ± 3 (-10)	1 ± 1 (-9)	1 ± 1 (-8)	11 ± 1
¹²⁵ Sb	<5.8 (-3)	<1.2 (-11)	<5.0 (-11)	<1.8 (-11)	>11.2
¹³⁴ Cs	<2.1 (-2)	<1.0 (-11)	<1.7 (-10)	<2.8 (-10)	>10.1
¹³⁷ Cs	1.2 (-2)	1.8 ± 0.6 (-10)	7 ± 2 (-11)	7 ± 2 (-11)	10.7 ± 0.3
²⁴¹ Pu	— ^d	<1.3 (-12)	<3.4 (-12)	<1.3 (-13)	>12.9
Metal		($\mu\text{g}/\text{cm}^2\cdot\text{s}$)			
Chromium	<4.1 (-3) ^c	<3.3 (-6)	<3.9 (-11)	<6.0 (-12)	>11.7
Iron	1.8 (-3) ^c	1.0 ± 0.5 (-5)	9 ± 4 (-12)	2 ± 1 (-12)	12.7 ± 0.6
Cobalt	<4.3 (-2) ^c	<1.6 (-5)	<4.1 (-10)	<5.4 (-10)	>9.6
Nickel	<9.8 (-3) ^c	<1.3 (-5)	<9.4 (-11)	<2.8 (-11)	>10.9

a. Results are for only the first 90 days of leaching.

b. Fraction of initial inventory released per square centimeter of specimen surface area per second.

c. Not all leachate samples were analyzed for this radionuclide or metal. CFR value was estimated by interpolating measured incremental release rates.

d. Only the leachate corresponding to leaching interval number three was analyzed for ²⁴¹Pu. Leaching results are those determined for leaching interval number three.

Table 9. Leach test results for Brunswick Unit 1 cation resin waste-form specimen leached in synthetic Barnwell ground water with pH 10.4^a

Nuclide	CFR	Release Rate		Average Effective Diffusivity (cm ² /s)	Leachability Index
		($\mu\text{Ci}/\text{cm}^2\cdot\text{s}$)	(F/cm ² ·s) ^b		
⁵⁴ Mn	<1.3 (-5)	<1.3 (-11)	<1.3 (-13)	<1.8 (-16)	>16.4
⁵⁵ Fe	5.1 (-5) ^c	9 ± 7 (-11)	2 ± 1 (-13)	5 ± 3 (-16)	15.8 ± 0.4
⁵⁸ Co	<2.2 (-3)	<2.3 (-10)	<2.2 (-11)	<7.4 (-12)	>11.9
⁶⁰ Co	1.1 (-5)	2.7 ± 0.9 (-11)	5 ± 2 (-14)	8 ± 5 (-17)	16.6 ± 0.2
⁶³ Ni	5.8 (-4) ^c	5 ± 4 (-10)	5 ± 4 (-12)	3 ± 3 (-13)	13.6 ± 0.5
⁶⁵ Zn	<2.9 (-4)	<1.7 (-11)	<2.5 (-12)	<9.3 (-14)	>13.6
⁹⁰ Sr	4.2 (-2) ^c	7 ± 3 (-12)	3 ± 1 (-11)	1.4 ± 0.9 (-10)	11.2 ± 0.6
¹²⁵ Sb	<5.7 (-3)	<1.7 (-11)	<6.8 (-11)	<3.2 (-11)	>11.0
¹³⁴ Cs	<2.1 (-2)	<1.5 (-11)	<2.5 (-10)	<5.3 (-10)	>9.9
¹³⁷ Cs	1.1 (-2)	2.3 ± 0.9 (-10)	9 ± 3 (-11)	8 ± 2 (-11)	10.5 ± 0.3
²⁴¹ Pu	— ^d	<1.5 (-12)	<3.9 (-12)	<1.7 (-13)	>12.8
Metal		($\mu\text{g}/\text{cm}^2\cdot\text{s}$)			
Chromium	<1.8 (-2) ^c	<1.4 (-5)	<1.6 (-10)	<1.1 (-10)	>10.5
Iron	<6.5 (-3) ^c	<1.1 (-4)	<9.0 (-11)	<3.6 (-11)	>10.7
Cobalt	<2.1 (-1) ^c	<7.3 (-5)	<1.8 (-9)	<1.5 (-8)	>8.1
Nickel	<4.9 (-2) ^c	<5.8 (-5)	<4.2 (-10)	<8.0 (-10)	>9.4

a. Results are for only the first 90 days of leaching.

b. Fraction of initial inventory released per square centimeter of specimen surface area per second.

c. Not all leachate samples were analyzed for this radionuclide or metal. CFR value was estimated by interpolating measured incremental release rates.

d. Only the leachate corresponding to leaching interval number three was analyzed for ²⁴¹Pu. Leaching results are those determined for leaching interval number three.

Table 10. Leach test results for Brunswick Unit 1 cation resin waste-form specimen leached in synthetic Barnwell ground water with pH 4.2^a

Nuclide	CFR	Release Rate		Average Effective Diffusivity (cm ² /s)	Leachability Index
		($\mu\text{Ci}/\text{cm}^2\cdot\text{s}$)	($\text{F}/\text{cm}^2\cdot\text{s}$) ^b		
⁵⁴ Mn	<8.2 (-6)	<6.7 (-12)	<7.4 (-14)	<3.5 (-17)	>16.9
⁵⁵ Fe	2.2 (-5) ^c	2 ± 1 (-11)	4 ± 2 (-14)	9 ± 6 (-17)	16.6 ± 0.4
⁵⁸ Co	<2.6 (-3)	<2.6 (-10)	<2.8 (-11)	<4.3 (-12)	>11.9
⁶⁰ Co	7.6 (-6)	1.9 ± 0.8 (-11)	4 ± 2 (-14)	2.0 ± 0.6 (-17)	17.0 ± 0.2
⁶³ Ni	4.6 (-4) ^c	1.7 ± 0.8 (-10)	1.9 ± 0.9 (-12)	9 ± 4 (-14)	13.6 ± 0.5
⁶⁵ Zn	<3.5 (-4)	<1.4 (-11)	<2.3 (-12)	<8.4 (-14)	>13.7
⁹⁰ Sr	9.9 (-4) ^c	3 ± 2 (-12)	1.0 ± 0.6 (-11)	5 ± 2 (-13)	13.0 ± 0.5
¹²⁵ Sb	<5.4 (-3)	<1.1 (-11)	<4.8 (-11)	<1.7 (-11)	>11.3
¹³⁴ Cs	<2.3 (-2)	<1.0 (-11)	<1.9 (-10)	<3.1 (-10)	>10.1
¹³⁷ Cs	1.1 (-2)	2 ± 1 (-10)	9 ± 4 (-11)	8 ± 2 (-11)	10.7 ± 0.4
²⁴¹ Pu	— ^d	8.0 (-13)	2.3 (-12)	4.7 (-14)	13.3
Metal		($\mu\text{g}/\text{cm}^2\cdot\text{s}$)			
Chromium	<2.3 (-2) ^c	<1.5 (-5)	<2.0 (-10)	<1.2 (-10)	>10.3
Iron	<7.1 (-3) ^c	<1.1 (-4)	<1.0 (-10)	<3.3 (-11)	>10.8
Cobalt	<2.5 (-1) ^c	<7.6 (-5)	<2.1 (-9)	<1.4 (-8)	>8.2
Nickel	<5.7 (-2) ^c	<6.0 (-5)	<4.8 (-10)	<7.2 (-10)	>9.5

a. Results are for only the first 90 days of leaching.

b. Fraction of initial inventory released per square centimeter of specimen surface area per second.

c. Not all leachate samples were analyzed for this radionuclide or metal. CFR value was estimated by interpolating measured incremental release rates.

d. Only the leachate corresponding to leaching interval number three was analyzed for ²⁴¹Pu. Leaching results are those determined for leaching interval number three.

Table 11. Leach test results for Brunswick Unit 1 cation resin waste-form specimen leached in synthetic Hanford ground water with pH 8.9^a

Nuclide	CFR	Release Rate		Average Effective Diffusivity (cm ² /s)	Leachability Index
		(μCi/cm ² ·s)	(F/cm ² ·s) ^b		
⁵⁴ Mn	<1.3 (-5)	<9.5 (-12)	<1.1 (-13)	<2.0 (-16)	>16.7
⁵⁵ Fe	2.3 (-5) ^c	3 ± 2 (-11)	6 ± 4 (-14)	3 ± 3 (-16)	16.7 ± 0.6
⁵⁸ Co	<2.2 (-3)	<2.3 (-10)	<2.5 (-11)	<2.7 (-12)	>12.1
⁶⁰ Co	1.2 (-5)	2.0 ± 0.6 (-11)	4 ± 1 (-14)	1 ± 1 (-16)	16.9 ± 0.3
⁶³ Ni	1.2 (-3) ^c	1.0 ± 0.8 (-9)	1.1 ± 0.9 (-11)	8 ± 6 (-13)	14.0 ± 1
⁶⁵ Zn	<3.3 (-4)	<1.3 (-11)	<2.2 (-12)	<5.0 (-14)	>13.8
⁹⁰ Sr	1.4 (-3) ^c	2 ± 1 (-12)	8 ± 5 (-12)	1.0 ± 0.8 (-12)	12.9 ± 0.4
¹²⁵ Sb	<5.4 (-3)	<1.2 (-11)	<5.3 (-11)	<1.5 (-11)	>11.3
¹³⁴ Cs	<1.9 (-2)	<1.0 (-11)	<1.9 (-10)	<2.1 (-10)	>10.3
¹³⁷ Cs	1.2 (-2)	3 ± 1 (-10)	1.1 ± 0.5 (-10)	9 ± 2 (-11)	10.8 ± 0.4
²⁴¹ Pu	— ^d	1.2 (-12)	3.6 (-12)	1.2 (-13)	12.9
Metal		(μg/cm ² ·s)			
Chromium	<2.2 (-2) ^c	<1.5 (-5)	<2.0 (-10)	<1.1 (-10)	>10.3
Iron	<1.2 (-2) ^c	<1.1 (-4)	<1.0 (-10)	<3.0 (-11)	>10.9
Cobalt	<2.4 (-1) ^c	<7.4 (-5)	<2.1 (-9)	<1.3 (-8)	>8.2
Nickel	<5.6 (-2) ^c	<5.9 (-5)	<4.9 (-10)	<6.8 (-10)	>9.5

a. Results are for only the first 90 days of leaching.

b. Fraction of initial inventory released per square centimeter of specimen surface area per second.

c. Not all leachate samples were analyzed for this radionuclide or metal. CFR value was estimated by interpolating measured incremental release rates.

d. Only the leachate corresponding to leaching interval number three was analyzed for ²⁴¹Pu. Leaching results are those determined for leaching interval number three.

Table 12. Leach test results for Brunswick Unit 1 cation resin waste-form specimen leached in synthetic seawater with pH 6.4^a

Nuclide	CFR	Release Rate		Average Effective Diffusivity (cm ² /s)	Leachability Index
		(μCi/cm ² ·s)	(F/cm ² ·s) ^b		
⁵⁴ Mn	<1.1 (-5)	<9.6 (-12)	<1.1 (-13)	<1.4 (-16)	>16.5
⁵⁵ Fe	— ^c	— ^c	— ^c	— ^c	— ^c
⁵⁸ Co	<3.2 (-3)	<4.7 (-10)	<5.0 (-11)	<2.0 (-11)	>11.7
⁶⁰ Co	1.9 (-5)	1.1 ± 0.9 (-10)	2 ± 2 (-13)	1 ± 1 (-15)	16.4 ± 0.3
⁶³ Ni	— ^c	— ^c	— ^c	— ^c	— ^c
⁶⁵ Zn	<3.4 (-4)	<1.9 (-11)	<3.2 (-12)	<1.8 (-13)	>13.5
⁹⁰ Sr	— ^c	— ^c	— ^c	— ^c	— ^c
¹²⁵ Sb	<5.7 (-3)	<1.2 (-11)	<5.6 (-11)	<2.5 (-11)	>11.0
¹³⁴ Cs	2.9 (-2)	1.8 ± 0.9 (-11)	3 ± 2 (-10)	9 ± 6 (-10)	9.7 ± 0.3
¹³⁷ Cs	1.5 (-2)	3 ± 1 (-10)	1.4 ± 0.6 (-10)	1.8 ± 0.9 (-10)	10.3 ± 0.3
²⁴¹ Pu	— ^d	2.1 (-12)	5.9 (-12)	3.4 (-13)	12.5
Metal		(μg/cm ² ·s)			
Chromium	8.1 (-2) ^e	4 ± 2 (-5)	5 ± 3 (-10)	1.3 ± 0.7 (-9)	9.1 ± 0.2
Iron	<1.3 (-2) ^e	<1.3 (-4)	<1.2 (-10)	<5.4 (-11)	>10.6
Cobalt	<2.6 (-1) ^e	<8.8 (-5)	<2.5 (-9)	<2.3 (-8)	>7.9
Nickel	<5.9 (-2) ^e	<7.0 (-5)	<5.7 (-10)	<1.2 (-9)	>9.2

a. Results are for only the first 90 days of leaching.

b. Fraction of initial inventory released per square centimeter of specimen surface area per second.

c. Concentrations of radionuclide in leachate samples were not determined.

d. Only the leachate corresponding to leaching interval number three was analyzed for ²⁴¹Pu. Leaching results are those determined for leaching interval number three.

e. Not all leachate samples were analyzed for this metal. CFR value was estimated by interpolating measured incremental release rates.

decontamination process. ^{90}Sr and ^{137}Cs are fission products that have low concentrations and are only indicative of the degree of fuel failure and contamination in the reactor coolant system. Other important neutron activation products released by the decontamination process (e.g., ^{54}Mn , ^{55}Fe , and ^{60}Co) have CFRs that are a factor of 3–4 lower than ^{63}Ni . For the decontamination radionuclides, the average release rates, expressed as both absolute and fractional rates, are highest for ^{55}Fe and ^{63}Ni . The lowest leachability index is for ^{137}Cs (10.7), a fission product, and is well above the BTP standard. Of the activated metals removed from surfaces by the Citrox/AP/Citrox process, the lowest leachability index is 14.5 for ^{63}Ni .

The release rates and the leachability index for ^{241}Pu were measured for the third sample period for each sample when the concentration would be expected to be highest. The concentrations were determined to be near the detection limit for the analysis. Consequently, only this sample was analyzed. The results indicate for all Brunswick-1 leachates that the leachability indexes of ^{241}Pu are well above the BTP standard of 6.0.

Table 9 lists the leach test results for the Brunswick-1 cation resin waste-form specimen leached in synthetic Barnwell ground water with a pH of 10.4. The radionuclides with the highest CFRs that were removed by the decontamination process were ^{63}Ni and ^{55}Fe . The CFRs of these radionuclides were, respectively, about 70% higher and a factor of 5 lower than the corresponding values for deionized water, which suggest leachant-specific differences in radionuclide behavior.

Nickel-63 and ^{55}Fe had the highest absolute and fractional release rates for the decontamination radionuclides measured, as indicated in Table 9. The absolute release rate of ^{63}Ni was about a factor of 5 higher than that from ^{55}Fe . In contrast, the fractional release rate of ^{63}Ni was about 1 order of magnitude higher, which suggests different release rates for the two radionuclides. However, all radionuclides had leachability indexes greater than the BTP stan-

dard, with ^{63}Ni having the lowest (13.4) of the activation products that were measured. In contrast, there was insufficient stable metal in the leach solutions to calculate actual CFRs, release rates, and leachability indexes. However, calculations were performed using detection-limit concentrations, which indicated that all stable metals had leachability indexes greater than 6.0.

The leachability data for the Brunswick-1 cation resin samples leached in synthetic Barnwell ground water with pH 4.2, as shown in Table 10, are very similar to leachability data for the synthetic Barnwell water with pH 10 (Table 9) with several exceptions. Although the CFRs of ^{63}Ni are essentially identical for both pH levels, the CFRs of ^{90}Sr were 42 times less for the pH 4.2 leachate than for the pH 10.4 leachate. The effects of the difference in pH on the CFRs of various radionuclides are evaluated in the discussion section.

The leach-test results for the Brunswick-1 cation resin waste-form specimen leached in synthetic Hanford ground water with pH 8.9 are shown in Table 11. Again, the principal decontamination-process product released was ^{63}Ni . The CFR and release rates, both absolute and fractional for this radionuclide, were between a factor of 2 and 3 higher for this leachant than for the other leachants. The reason for the higher release of ^{63}Ni for this leachant is not known but will be discussed in the discussion section.

The leachability indexes for all radionuclides and stable metals were above the BTP requirement of 6.0. Similar to the other cation resin samples, there were insufficient data to calculate the CFR and leachability indexes for the stable metals.

Of the decontamination radionuclides listed in Table 12, which shows the leaching results for the Brunswick-1 cation resin waste-form specimen in seawater, only ^{60}Co was detected at measurable levels. The concentrations of ^{55}Fe and ^{63}Ni were not measured because the high concentrations of other elements made it difficult to separate these elements and perform an accurate analysis of the concentrations of these

radionuclides in the leachates. Comparison of the results for ^{60}Co from seawater and deionized water indicates a reduction of about a factor of 4 in the CFR from seawater and a factor of 2 in the fractional release rate from deionized water. The effects of the high ion content of the seawater on radionuclide release is addressed in the discussion section.

As shown in Table 12, only the leachability index for chromium was calculable for the seawater sample. The CFRs and leachability indexes for the other elements were calculated using detection-limit values. The release rate for chromium was higher than any of the radionuclides. This relatively high release rate will be evaluated in the discussion of the results section. Leachability indexes calculated for stable metals, using detection limits for elements other than chromium, were well above the guidelines set by the NRC.

Leachant Effects on Radionuclides, Chelating Agents, and Stable Metals from Brunswick-1 Cation Resin Waste-Form Specimens. One of the important objectives of this project is to assess the effects of different leachants on the releases of radionuclides, chelating agents, and stable metals from waste-form specimens being leached. The following sections present comparisons of the CFRs, average release rates, and leachability indexes for principal radionuclides and stable metals. The principal radionuclides evaluated are ^{60}Co , ^{63}Ni , and ^{55}Fe . Comparisons of results for other radionuclides will be summarized at the end of this section along with a summary of the results obtained during the long-term leaching of several samples.

Leachant Effects on the Release of Radionuclides from Brunswick-1 Cation Resin Waste Form Specimens—Leachant effects on the release of radionuclides are evaluated through comparisons of cumulative fractional releases, average release rates, and leachability indexes of the radionuclides for which measurements were performed. A comparison of the cumulative fractional releases from Brunswick-1 cation resin waste-form specimens for the principal radionuclides released by the

decontamination process are shown in Figures 18 through 20 for ^{60}Co , ^{63}Ni , and ^{55}Fe , respectively. In addition, the CFR data for ^{137}Cs , a fission product, are shown in Figure 21 for comparison with the decontamination products. The ^{60}Co data are shown first although the CFRs of this radionuclide are lower than those for ^{63}Ni and ^{55}Fe , because the associated uncertainties are less for these data as discussed in the experimental procedures section. ^{60}Co concentrations in leachate samples were measured by gamma spectroscopy without the chemical separations required for the beta-emitting radionuclides and, therefore, provide a good basis for comparison with the release behavior of other radionuclides.

CFRs of ^{60}Co from the five cation resin waste-form specimens are plotted as a function of the square root of leaching time in Figure 18. The data presented in Figure 18 show that only very small fractions of ^{60}Co were leached from the waste-form specimens (a factor of 6 to 17 higher after 90 days), and that the releases of ^{60}Co were much higher in deionized water than in any of the other four leachants. The total quantities of ^{60}Co released from the five waste-form specimens, expressed as percent of initial inventory, ranged from 0.0009% for the specimen leached in leachant with pH 4.2 to 0.01% for the specimen leached in deionized water.

Examination of Figure 18 indicates that the sample leached in deionized water had initial high CFRs of ^{60}Co through the early part of the leach test (about 5 days). First, the CFR from the seawater sample stabilized into a diffusion-driven release, followed by the other leachants as might be expected because the sample leached in seawater retained its shape whereas the other samples had begun to decompose. At least initially, the higher release rates may have been driven by the exposure of new surfaces as the samples disintegrated. However, the fact that the leachability of the ground water samples stabilized at about the same time as the deionized water suggests that much of the initial release is driven by the formation of a concentration gradient at the surface of the sample or debris pile which would tend to retard the release of ^{60}Co

Figure 18. Cumulative fraction release of ^{60}Co from five Brunswick Unit 1 cation resin waste-form specimens.

Figure 19. Cumulative fraction release of ^{63}Ni from five Brunswick Unit 1 cation resin waste-form specimens.

Figure 20. Cumulative fraction release of ^{55}Fe from five Brunswick Unit 1 cation resin waste-form specimens.

Figure 21. Cumulative fraction release of ^{137}Cs from five Brunswick Unit 1 cation resin waste-form specimens.

from the freshly exposed surfaces. The seawater sample is not considered indicative because that sample retained its structural shape, whereas the other samples began decomposing almost immediately. Mechanisms that would tend to retard the release from waste-form specimens in natural ground waters are presented in the discussion section.

The data plotted in Figure 18 show that releases of ^{60}Co were similar for all leachates after the initial 5-day period. Through the remainder of the 90-day leaching period, the linearity of the CFRs indicates that leaching from the waste-form specimen was probably being driven by diffusion. Consequently, the higher initial releases from the specimen leached in deionized water were probably driven by surface release mechanisms that result in a steeper concentration gradient formed with the deionized water.

Of particular importance to the assessment of the CFRs of ^{60}Co is the fact that the ground water and deionized water waste-form specimens crumbled into granular debris within a few days. However, the CFRs from the samples leached in ground waters were about a factor of two lower than cumulative releases of ^{60}Co from the specimen leached in seawater that remained more or less intact during leaching. Because the seawater leachant contained relatively high concentrations of NaCl and Na_2SO_4 (see Table 5), the higher cumulative release of ^{60}Co from the specimen leached in seawater compared to corresponding releases from the specimens leached in synthetic ground waters suggests that cobalt may have formed soluble compounds with chloride and sulfate anions in the seawater leachates, which increased the release from this relatively intact waste-form specimen. In contrast, cobalt may have formed insoluble compounds with carbonate and hydroxide anions in the ground water samples, which may have precipitated out of the leachate solutions. The possible chemistry associated with releases from the cation resin waste-form specimen is evaluated in the discussion section.

A comparison of the CFRs of ^{63}Ni from four Brunswick-1 cation resin waste-form specimens is shown in Figure 19. The CFRs of this radionuclide were between a factor of 4 and 100, higher than those of ^{60}Co . Examination of Figure 19 indicates differences in the leachability characteristics of ^{63}Ni as compared to ^{60}Co . In the case of ^{60}Co , the sample leached in deionized water has the highest CFR, whereas for ^{63}Ni , the Hanford ground water with a pH of 8.9 has a CFR about a factor of 3 greater than the sample leached in deionized water. The CFRs of ^{63}Ni and ^{60}Co both stabilize in a diffusion-controlled release after 5 days into the leaching period. These data suggest that leachant- and radionuclide-specific factors may substantially affect the CFR from waste-form specimens. These observations are discussed in greater detail in the discussion section.

The CFRs of ^{55}Fe from the Brunswick-1 cation resin waste-form specimen are plotted in Figure 20. The CFRs of ^{55}Fe are lower than the ^{63}Ni CFRs by 1-2 orders of magnitude. For this radionuclide, the leachant with the highest CFRs is deionized water. The CFR curves of ^{55}Fe are very similar to those of ^{60}Co , although the CFR of ^{55}Fe in deionized water is about a factor of 3 higher than the CFR of ^{60}Co in the same leachant. These data suggest that the CFR of various radionuclides is strongly dependant on the radionuclide being released or possibly the concentration of the radionuclide in the leachate. Further evaluation of these effects is presented in the discussion section.

The CFRs of other radionuclides were not plotted except for those shown in Appendix E and the ^{137}Cs data, which are shown for comparison purposes. However, examinations of the leachant effects on all fission products indicate radionuclide-specific differences in the leachant effect on the waste-form specimen, which apparently controlled the quantity released and the time during the leaching period when the release occurred. An examination of the ^{137}Cs data in Figure 21 indicates that the leachant resulting in the highest CFR was seawater. In contrast, the deionized water CFR curve was below both the

seawater and the Hanford ground water with pH 8.9.

In addition to the comparison of the CFRs for various leachants, comparisons of the absolute and fractional release rates for the decontamination radionuclides were also performed. The average fractional release rate, which is expressed as the fraction of initial inventory released per second per square centimeter of specimen surface area, provides an indication of the radionuclide release rate from the specimen and an indication of when the release occurred. The radionuclides (i.e., ^{60}Co , ^{63}Ni , and ^{55}Fe) produced by the decontamination process are evaluated in this section along with the ^{137}Cs results for comparison purposes.

A comparison of the absolute release rates for the decontamination radionuclides at 90 days indicates that, for ^{55}Fe , the highest absolute release rate was $1 \times 10^{-9} \mu\text{Ci}/\text{cm}^2\cdot\text{s}$ for the sample leached in deionized water. For ^{63}Ni , the sample leached in Hanford ground water pH 8.9 had the highest absolute release rate ($1.0 \times 10^{-9} \mu\text{Ci}/\text{cm}^2\cdot\text{s}$). In contrast, the absolute release rate of ^{137}Cs into all leachants was similar at $1.8\text{--}2.3 \times 10^{-10} \mu\text{Ci}/\text{cm}^2\cdot\text{s}$. These data suggest radionuclide- and leachant-specific differences in the absolute release rates.

Figure 22 shows the fractional release rate of ^{60}Co for all five Brunswick-1 cation waste-form specimens. The average release rates decreased significantly after 5 days, when the leaching interval was increased from 24 h to 13 days. Releases occurring during the initial fast-release period (i.e., 0 to 5 days) accounted for 88% of the total quantity of ^{60}Co released from the waste-form specimen leached in deionized water at the end of the initial 90-day leaching period. Similarly, about 60% of the total quantity of ^{60}Co released from the remaining four waste-form specimens during 90 days of leaching was released during the first 5 days. The similarity of the release rate data for the relatively intact sample that was leached in seawater and the samples that decomposed suggests that the activity slowly

diffused out of the granular rubble in the debris bed in a release similar to the diffusion-driven release from the sample leached in seawater. The high release rate that occurred during the second interval for the sample leached in seawater corresponds to the moment that the sample split into two parts.

Evaluation of the fractional release rates of ^{63}Ni (Figure 23) and ^{55}Fe (Figure 24) indicates similar trends to those observed for ^{60}Co with much of the release occurring early in the leach test probably due to surface effects.

Evaluation of the fractional release rates of other radionuclides indicates similar patterns to those observed for ^{60}Co . The ^{137}Cs release rate data are plotted in Figure 25 and indicate that the releases of ^{137}Cs were slightly higher in seawater than in any of the other four leachants, but that the pattern of the release rate data is similar to ^{60}Co .

As shown in Figure 25, during the first 5 days of leaching, the fractional release rates of ^{137}Cs were very similar for all leachants, despite the fact that the deteriorations of the waste-form specimens were different during that time. With the exception of the results for the seawater leachant, maximum release rates of ^{137}Cs occurred during the first leaching interval, which was 2 h long. In the case of seawater, the maximum occurred during the second leaching when the specimen cracked and split into two pieces. The high release rates of ^{137}Cs during the first 5 days of leaching are likely the result of the washing of newly exposed surfaces through contact with the leachates. However, the fact that the fractional release rates of ^{137}Cs from the five waste-form specimens were so similar, and did not exhibit the variability of ^{60}Co release rates, indicates that releases of ^{137}Cs during the first 5 days of leaching were also being governed by diffusion or other release mechanisms. Typically, after the leaching periods were extended (after 5 days), the release rates dropped substantially, suggesting the formation of an equilibrium between the leachant and the surface of the waste-form specimen.

Figure 22. Fractional release rate of ^{60}Co from five Brunswick Unit 1 cation resin waste-form specimens.

Figure 23. Fractional release rate of ^{63}Ni from five Brunswick Unit 1 cation resin waste-form specimens.

Figure 24. Fractional release rate of ^{55}Fe from five Brunswick Unit 1 cation resin waste-form specimens.

Figure 25. Fractional release rate of ^{137}Cs from five Brunswick Unit 1 cation resin waste-form specimens.

Leachability indexes of eight radionuclides for the 90-day leach period for the Brunswick-1 cation resin waste-form specimens are presented in Tables 8-12. The results show that leachability indexes of radionuclides ranged from a low of 10.1 for ^{137}Cs in leachant with pH 10.4 to a high of 16.7 for ^{60}Co in leachants with pH 4.2 and 8.9. The leachability indexes for all radionuclides were substantially greater than 6 as defined in the NRC's Technical Position on Waste Form. Leachability indexes of ^{54}Mn and ^{60}Co in deionized water were lower than leachability indexes of these radionuclides in other leachants, while leachability indexes of ^{55}Fe , ^{63}Ni , ^{90}Sr , and ^{137}Cs were similar for all leachants.

Leachant Effects on the Release of Chelating Agents from Brunswick-1 Cation Resin Waste-Form Specimens—

Releases were not calculated for the chelating agents, oxalic and citric acids, because they would not be expected to be substantially concentrated on a cation resin. Consequently, the cation resin waste-form samples were not analyzed for these chelating agents.

Leachant Effects on the Release of Stable Metals from Brunswick-1 Cation Resin Waste-Form Specimens—

Leachant effects on the release of stable metals are discussed through comparisons of the leachability indexes for the stable metals for which measurements were performed. The CFRs of stable metals were not plotted because the concentrations of stable metals in leachates were normally below the detection limits of the instruments used to perform the measurements.

The leachability indexes of chromium, iron, cobalt, and nickel for the Brunswick Unit 1 cation resin waste-form specimens are summarized in Tables 8 through 12. The leachability indexes of the four metals measured ranged from >7.7 for cobalt in leachant with pH 8.9 to 12.2 for iron in deionized water. Nickel and cobalt were not detected in any of the leachate samples that were analyzed for stable metals, and chromium was detected in only the seawater leachate samples and in two deionized water leachate samples.

Iron was detected in all of the deionized water leachates that were analyzed for stable metals and in three of the five Barnwell ground water leachants analyzed. However, as shown in Table 5, 0.69 mg/L of iron (III) nitrate, $\text{Fe}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$, was added to the Barnwell ground water leachants during their preparation. Therefore, the initial concentration of iron in the Barnwell ground water leachants was about 95 $\mu\text{g/L}$. Therefore, the leachability indexes of iron given for the two Barnwell ground water leachants are based on the ICP-AES detection-limit concentration reported for iron for the two leachants.

Brunswick-1 Cation Resin Long-Term Leaching Results.

After the initial 90-day leaching period, the leaching of all samples was continued through 201 days, except for the deionized water sample, which was continued for a total of 388 days. Results for the various radionuclides are shown in Figures 18 through 25 and are tabulated in Appendix G. The results generally followed the trends observed during the 90-day leaching period. However, some long-term effects occurred such as the increase in the ^{60}Co release rates measured after 170 days of leaching (see Figure 22). Between 170 and 200 days of leaching, portions of several specimens that had remained in the support nets fell to the bottoms of the leaching containers and may have resulted in an increase in the activity measured.

Results of Brunswick-1 Mixed-Bed Resin Waste-Form Specimens.

The following sections discuss the leaching test results for Brunswick Unit 1 mixed-bed resin waste-form specimens. The results discussed are leachate pH and conductivity; the releases of radionuclides, chelating agents, and stable metals from the waste-form samples; a comparison of the effects of different leachants on releases and leachability indexes; and a summary of long-term leaching behavior.

Brunswick-1 Mixed-Bed Resin Leachate pH and Conductivity.

This section presents leachant pH and conductivity data for the Brunswick-1 mixed-bed resins. The pH and conductivities of the leachates at the end of each

leaching interval are plotted in Figures 26 and 27, respectively. The different leachants are identified as Barnwell ground water pH 10.4 (BGW pH 10.4), deionized water pH 7.0 (DW), Hanford ground water pH 8.9 (HGW), Barnwell ground water pH 4.2 (BGW pH 4.2) and seawater (SW).

As was the case with the cation resin waste-form leachates, the final pH of the deionized water and synthetic ground water leachates for the mixed-bed resin waste-form specimens were very similar throughout the leach test. At the end of the initial 2-h leaching interval, the pH of these four leachates ranged from 12.2 to 12.3. During the first day of leaching, when leachates were changed out after elapsed times of 2, 7, and 24 h, the final pH of these four leachates remained unchanged. However, the leachate pH then declined slightly during the subsequent three leaching intervals (24 hours each) to between 11.5 and 11.8. When the leaching time was increased from 1 to 13 days for the eighth leaching period, the pH of the four leachates increased to about 12.0. The pH behavior as a function of leaching time is very similar to that observed for the cation resin and suggests that differences in the waste resins that were solidified do not substantially affect the pH of the leachate; only the cement affects the leachate pH, and that effect occurs soon (within hours) after the sample is placed in these leachants.

Leachate conductivities shown in Figure 27 ranged from 4.6 to 6.0 mmho/cm after the initial 2 h of leaching. They decreased to minima ranging between 0.3 and 0.8 mmho/cm after 5 days. Between 5 and 90 days, leachate conductivities rose to maxima between 3.8 and 4.2 mmho/cm. As was the case with the Brunswick-1 cation resin waste-form leachates, conductivities dropped significantly during the twelfth leaching (i.e., from 170 to 200 days) with conductivities falling to between 2.5 and 3.0 mmho/cm. The reason for this behavior is not known, but will be evaluated further in the discussion section. The conductivities measured for the Brunswick-1 mixed-bed resin are similar to those measured for the cation resin and again suggest that the cement chemistry determines the pH of the leachant.

Releases of Radionuclides, Chelating Agents, and Stable Metals from Brunswick-1 Mixed-Bed Resin Waste-Form Specimens. This section presents the leaching results for the release of radionuclides, chelating agents, and stable metals from Brunswick-1 mixed-bed waste-form specimens. The results are presented as cumulative fractional releases, average release rates, and leachability indexes for the five samples that were leached. Concentration of the radionuclide and stable metal leaching concentrations on which these values are based are shown in Appendix J, Tables J-6 through J-10; the concentrations of citric and oxalic acids in the leachate samples are presented in Appendix K, Table K-1. As shown in Appendix K, the concentrations of oxalic acid in seawater leachates were generally below the detection limit due to interferences with the sulfate peak during the ion chromatography analysis.

It should be noted that only selected leachate samples for the first ten leaching periods were analyzed for ^{55}Fe , ^{63}Ni , ^{90}Sr , and the stable metals, because it was determined that there would be no substantive impact on CFRs, average release rates, and leachability indexes. Also, measurements of the concentrations of ^{55}Fe , ^{63}Ni , and ^{90}Sr in the seawater leachates were not performed due to chemical separation problems similar to those discussed for the cation resin waste-form leachates.

Tables 13-17 show the cumulative fractional release (CFR), the absolute and fractional release rates, the effective diffusivity, and the leachability indexes for the radionuclides, chelating agents, and metals leached from Brunswick-1 mixed-bed resin waste-form specimens during the first 90 days of leach testing. Results for chelating agents, oxalic acid and citric acid are reported because they would be expected to be substantially concentrated on the anionic resins in the mixed-bed resin waste-form samples.

Table 13 summarizes the CFRs, release rates, and leachability indexes for the Brunswick-1 mixed-bed resin waste-form specimen leached

Figure 26. Leachate pH for five Brunswick-1 mixed-bed resin waste-form specimens.

Figure 27. Leachate conductivity for four Brunswick-1 mixed-bed resin waste-form specimens.

Table 13. Leach test results for Brunswick Unit 1 mixed-bed resin waste-form specimen leached in deionized water^a

Nuclide	CFR	Release Rate		Average Effective Diffusivity (cm ² /s)	Leachability Index
		($\mu\text{Ci}/\text{cm}^2\cdot\text{s}$)	($\text{F}/\text{cm}^2\cdot\text{s}$) ^b		
⁵⁴ Mn	<1.7 (-3)	<8.0 (-11)	<2.6 (-11)	<3.5 (-12)	>12.8
⁵⁵ Fe	1.1 (-2) ^c	1.3 $\pm$ 0.5 (-9)	6 $\pm$ 3 (-11)	9 $\pm$ 5 (-11)	11.0 $\pm$ 0.7
⁵⁸ Co	<9.9 (-2)	<3.4 (-10)	<8.6 (-10)	<4.8 (-9)	>8.7
⁶⁰ Co	1.3 (-3)	4 $\pm$ 2 (-10)	2 $\pm$ 1 (-11)	2 $\pm$ 2 (-12)	13.2 $\pm$ 0.5
⁶³ Ni	3.9 (-3) ^c	8 $\pm$ 5 (-11)	1.4 $\pm$ 0.8 (-11)	2.6 $\pm$ 0.7 (-12)	12.3 $\pm$ 0.8
⁶⁵ Zn	<1.0 (-2)	<2.8 (-11)	<1.0 (-10)	<4.9 (-11)	>10.7
⁹⁰ Sr	2.3 (-1) ^c	1.6 $\pm$ 0.7 (-10)	1.4 $\pm$ 0.6 (-9)	7 $\pm$ 4 (-8)	9 $\pm$ 1
¹²⁵ Sb	5.6 (-3)	4 $\pm$ 2 (-11)	6 $\pm$ 3 (-11)	2.0 $\pm$ 0.5 (-11)	11.2 $\pm$ 0.3
¹³⁴ Cs	<1.2 (-1)	<1.5 (-11)	<1.5 (-9)	<8.8 (-9)	>8.6
¹³⁷ Cs	2.2 (-1)	1.6 $\pm$ 0.9 (-10)	3 $\pm$ 2 (-9)	3 $\pm$ 1 (-8)	7.9 $\pm$ 0.2
²⁴¹ Pu	— ^d	1.8 (-12)	6.3 (-12)	2.6 (-13)	12.6
Chelating Agent or Metal					
		($\mu\text{g}/\text{cm}^2\cdot\text{s}$)			
Oxalic acid	6.3 (-3)	1.6 $\pm$ 0.7 (-4)	6 $\pm$ 2 (-11)	2.2 $\pm$ 0.7 (-11)	11.0 $\pm$ 0.2
Citric acid	4.0 (-3)	2 $\pm$ 1 (-4)	4 $\pm$ 2 (-11)	1.4 $\pm$ 0.7 (-11)	11.5 $\pm$ 0.3
Chromium	<1.9 (-3) ^c	<3.5 (-6)	<1.6 (-11)	<1.5 (-12)	>12.3
Iron	<2.1 (-2) ^c	<1.6 (-5)	<1.7 (-10)	<1.5 (-10)	>10.5
Cobalt	<4.3 (-2) ^c	<1.3 (-5)	<3.0 (-10)	<4.9 (-10)	>9.6
Nickel	<1.6 (-1) ^c	<1.0 (-5)	<1.1 (-9)	<6.7 (-9)	>8.5

a. Results are for only the first 90 days of leaching.

b. Fraction of initial inventory released per square centimeter of specimen surface area per second.

c. Not all leachate samples were analyzed for this radionuclide or metal. CFR value was estimated by interpolating measured incremental release rates.

d. Only the leachate corresponding to leaching interval number three was analyzed for ²⁴¹Pu. Leaching results are those determined for leaching interval number three.

Table 14. Leach test results for Brunswick Unit 1 mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with pH 10.4^a

Nuclide	CFR	Release Rate		Average Effective Diffusivity (cm ² /s)	Leachability Index
		(μCi/cm ² ·s)	(F/cm ² ·s) ^b		
⁵⁴ Mn	<3.4 (-4)	<9.4 (-12)	<3.5 (-12)	<7.7 (-14)	>13.7
⁵⁵ Fe	6.7(-4) ^c	7 ± 3 (-11)	4 ± 2 (-12)	2 ± 1 (-13)	13.4 ± 0.5
⁵⁸ Co	<9.4 (-2)	<3.2 (-10)	<9.1 (-10)	<4.9 (-9)	>8.8
⁶⁰ Co	2.2 (-4)	9 ± 7 (-11)	5 ± 4 (-12)	4 ± 3 (-14)	14.2 ± 0.3
⁶³ Ni	2.1 (-4) ^c	6 ± 3 (-12)	1.2 ± 0.7 (-12)	1.5 ± 0.8 (-14)	14.3 ± 0.4
⁶⁵ Zn	<9.2 (-3)	<2.6 (-11)	<1.1 (-10)	<6.7 (-11)	>10.8
⁹⁰ Sr	6.9 (-3) ^c	7 ± 4 (-12)	7 ± 4 (-11)	2 ± 2 (-11)	11.3 ± 0.4
¹²⁵ Sb	5.8 (-3)	8 ± 6 (-11)	1.3 ± 0.9 (-10)	3 ± 2 (-11)	11.3 ± 0.4
¹³⁴ Cs	<8.9 (-2)	<1.8 (-11)	<2.0 (-9)	<6.8 (-9)	>8.9
¹³⁷ Cs	1.6 (-1)	2 ± 2 (-10)	5 ± 4 (-9)	3 ± 2 (-8)	8.7 ± 0.4
²⁴¹ Pu	— ^d	2.0 (-12)	8.0 (-12)	3.1 (-13)	12.5
Chelating Agent or Metal					
		(μg/cm ² ·s)			
Oxalic acid	7.4 (-3)	3 ± 2 (-4)	1.1 ± 0.7 (-10)	3.0 ± 0.9 (-11)	11.0 ± 0.3
Citric acid	3.6 (-3)	3 ± 2 (-4)	6 ± 4 (-11)	8 ± 3 (-12)	11.6 ± 0.3
Chromium	<9.5 (-3) ^c	<2.0 (-5)	<1.0 (-10)	<2.1 (-11)	>11.0
Iron	<9.6 (-2) ^c	<1.5 (-4)	<1.8 (-9)	<6.3 (-9)	>8.5
Cobalt	<2.5 (-1) ^c	<9.9 (-5)	<2.8 (-9)	<1.5 (-8)	>8.2
Nickel	<8.1 (-1) ^c	<7.9 (-5)	<1.0 (-8)	<2.0 (-7)	>7.0

a. Results are for only the first 90 days of leaching.

b. Fraction of initial inventory released per square centimeter of specimen surface area per second.

c. Not all leachate samples were analyzed for this radionuclide or metal. CFR value was estimated by interpolating measured incremental release rates.

d. Only the leachate corresponding to leaching interval number three was analyzed for ²⁴¹Pu. Leaching results are those determined for leaching interval number three

Table 15. Leach test results for Brunswick Unit 1 mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with pH 4.2^a

Nuclide	CFR	Release Rate		Average Effective Diffusivity (cm ² /s)	Leachability Index
		(μCi/cm ² ·s)	(F/cm ² ·s) ^b		
⁵⁴ Mn	<3.0 (−4)	<1.1 (−11)	<3.7 (−12)	<4.4 (−14)	>13.8
⁵⁵ Fe	3.2 (−4) ^c	4 ± 2 (−11)	2 ± 1 (−12)	6 ± 4 (−14)	14.5 ± 0.9
⁵⁸ Co	<7.9 (−2)	<2.8 (−10)	<7.5 (−10)	<2.4 (−9)	>9.0
⁶⁰ Co	2.5 (−4)	8 ± 6 (−11)	4 ± 3 (−12)	4 ± 2 (−14)	14.2 ± 0.3
⁶³ Ni	3.1 (−4) ^c	1.2 ± 0.9 (−11)	2 ± 2 (−12)	3 ± 2 (−14)	14.5 ± 0.8
⁶⁵ Zn	<7.0 (−3)	<2.5 (−11)	<9.7 (−11)	<3.2 (−11)	>11.1
⁹⁰ Sr	1.5 (−3) ^c	2 ± 1 (−12)	1.8 ± 0.9 (−11)	9 ± 5 (−13)	13.1 ± 0.8
¹²⁵ Sb	6.0 (−3)	7 ± 5 (−11)	1.0 ± 0.7 (−10)	2 ± 1 (−11)	11.3 ± 0.3
¹³⁴ Cs	<1.4 (−1)	<2.7 (−11)	<2.9 (−9)	<1.5 (−8)	>8.7
¹³⁷ Cs	2.4 (−1)	3 ± 2 (−10)	6 ± 4 (−9)	1.1 ± 0.4 (−7)	7.2 ± 0.2
²⁴¹ Pu	— ^d	2.5 (−12)	9.2 (−12)	4.8 (−13)	12.3
Chelating Agent or Metal		(μg/cm ² ·s)			
Oxalic acid	9.0 (−3)	4 ± 3 (−4)	2 ± 1 (−10)	5 ± 2 (−11)	10.9 ± 0.3
Citric acid	8.4 (−3)	6 ± 4 (−4)	1.1 ± 0.8 (−10)	3 ± 1 (−11)	10.9 ± 0.2
Chromium	<7.9 (−3) ^c	<1.5 (−5)	<7.5 (−11)	<1.4 (−11)	>11.2
Iron	<8.3 (−2) ^c	<1.2 (−4)	<1.3 (−9)	<4.1 (−9)	>8.8
Cobalt	<1.9 (−1) ^c	<7.3 (−5)	<1.9 (−9)	<9.3 (−9)	>8.7
Nickel	<7.8 (−1) ^c	<6.2 (−5)	<7.4 (−9)	<1.4 (−7)	>7.2

a. Results are for only the first 90 days of leaching.

b. Fraction of initial inventory released per square centimeter of specimen surface area per second.

c. Not all leachate samples were analyzed for this radionuclide or metal. CFR value was estimated by interpolating measured incremental release rates.

d. Only the leachate corresponding to leaching interval number three was analyzed for ²⁴¹Pu. Leaching results are those determined for leaching interval number three.

Table 16. Leach test results for Brunswick Unit 1 mixed-bed resin waste-form specimen leached in synthetic Hanford ground water with pH 8.9^a

Nuclide	CFR	Release Rate		Average Effective Diffusivity (cm ² /s)	Leachability Index
		($\mu\text{Ci}/\text{cm}^2\cdot\text{s}$)	(F/cm ² ·s) ^b		
⁵⁴ Mn	<1.2 (-3)	<4.7 (-11)	<2.1 (-11)	<8.0 (-13)	>13.1
⁵⁵ Fe	7.6 (-4) ^c	7 ± 5 (-11)	5 ± 3 (-12)	1 ± 1 (-12)	13.8 ± 0.8
⁵⁸ Co	<1.3 (-1)	<2.4 (-10)	<8.3 (-10)	<8.7 (-9)	>8.8
⁶⁰ Co	8.4 (-4)	3 ± 2 (-10)	2 ± 2 (-11)	6 ± 4 (-13)	13.9 ± 0.4
⁶³ Ni	7.4 (-4) ^c	3 ± 3 (-11)	8 ± 7 (-12)	2 ± 2 (-13)	14.0 ± 0.8
⁶⁵ Zn	<1.2 (-2)	<2.9 (-11)	<1.5 (-10)	<4.4 (-11)	>10.8
⁹⁰ Sr	<9.8 (-4) ^c	<1.5 (-12)	<1.8 (-11)	<4.0 (-13)	>13.4
¹²⁵ Sb	6.3 (-3)	5 ± 3 (-11)	9 ± 6 (-11)	1.1 ± 0.4 (-11)	11.4 ± 0.2
¹³⁴ Cs	<9.2 (-2)	<7.2 (-12)	<9.9 (-10)	<2.4 (-9)	>9.0
¹³⁷ Cs	1.5 (-1)	1.1 ± 0.8 (-10)	3 ± 2 (-9)	9 ± 5 (-9)	8.9 ± 0.4
²⁴¹ Pu	— ^d	<1.4 (-12)	<6.9 (-12)	<1.6 (-13)	>12.8
Chelating Agent or Metal					
		($\mu\text{g}/\text{cm}^2\cdot\text{s}$)			
Oxalic acid	1.1 (-2)	2 ± 1 (-4)	1.1 ± 0.5 (-10)	3 ± 1 (-11)	10.9 ± 0.2
Citric acid	6.6 (-3)	4 ± 3 (-4)	9 ± 7 (-11)	1.1 ± 0.5 (-11)	11.4 ± 0.2
Chromium	<1.1 (-2) ^c	<1.3 (-5)	<8.0 (-11)	<1.9 (-11)	>11.1
Iron	<1.6 (-1) ^c	<8.2 (-5)	<1.2 (-9)	<3.8 (-9)	>9.2
Cobalt	<3.0 (-1) ^c	<6.4 (-5)	<2.1 (-9)	<1.3 (-8)	>8.3
Nickel	<8.0 (-1) ^c	<5.2 (-5)	<7.9 (-9)	<1.8 (-7)	>7.1

a. Results are for only the first 90 days of leaching.

b. Fraction of initial inventory released per square centimeter of specimen surface area per second.

c. Not all leachate samples were analyzed for this radionuclide or metal. CFR value was estimated by interpolating measured incremental release rates.

d. Only the leachate corresponding to leaching interval number three was analyzed for ²⁴¹Pu. Leaching results are those determined for leaching interval number three.

Table 17. Leach test results for Brunswick Unit 1 mixed-bed resin waste-form specimen leached in synthetic seawater with pH 6.4^a

Nuclide	CFR	Release Rate		Average Effective Diffusivity (cm ² /s)	Leachability Index
		($\mu\text{Ci}/\text{cm}^2\cdot\text{s}$)	($\text{F}/\text{cm}^2\cdot\text{s}$) ^b		
⁵⁴ Mn	<3.2 (-4)	<9.6 (-12)	<2.9 (-12)	<6.1 (-14)	>13.6
⁵⁵ Fe	— ^c	— ^c	— ^c	— ^c	— ^c
⁵⁸ Co	<9.3 (-2)	<3.1 (-10)	<7.0 (-10)	<4.7 (-9)	>8.7
⁶⁰ Co	4.5 (-4)	2.2 ± 0.9 (-11)	1.1 ± 0.4 (-12)	1.7 ± 0.8 (-14)	14.1 ± 0.2
⁶³ Ni	— ^c	— ^c	— ^c	— ^c	— ^c
⁶⁵ Zn	<8.0 (-3)	<1.8 (-11)	<6.1 (-11)	<5.2 (-11)	>10.9
⁹⁰ Sr	— ^c	— ^c	— ^c	— ^c	— ^c
¹²⁵ Sb	<2.7 (-3)	<1.5 (-11)	<1.9 (-11)	<3.3 (-12)	>11.8
¹³⁴ Cs	1.2 (-1)	9 ± 4 (-12)	8 ± 4 (-10)	5 ± 1 (-9)	8.5 ± 0.2
¹³⁷ Cs	2.6 (-1)	9 ± 4 (-11)	1.5 ± 0.6 (-9)	2.0 ± 0.3 (-8)	7.74 ± 0.06
²⁴¹ Pu	— ^d	<2.1 (-12)	<6.6 (-12)	<3.4 (-13)	>12.5
Chelating Agent or Metal		($\mu\text{g}/\text{cm}^2\cdot\text{s}$)			
Oxalic acid	— ^e	— ^e	— ^e	— ^e	— ^e
Citric acid	3.2 (-3)	2 ± 1 (-4)	4 ± 2 (-11)	8 ± 3 (-12)	11.6 ± 0.3
Chromium	5.1 (-2) ^f	5 ± 3 (-5)	2 ± 1 (-10)	2.1 ± 0.6 (-10)	9.7 ± 0.1
Iron	<1.1 (-1) ^f	<1.1 (-4)	<1.0 (-9)	<3.0 (-9)	>9.0
Cobalt	<1.9 (-1) ^f	<7.5 (-5)	<1.6 (-9)	<9.4 (-9)	>8.3
Nickel	<7.2 (-1) ^f	<6.0 (-5)	<6.0 (-9)	<1.3 (-7)	>7.2

a. Results are for only the first 90 days of leaching.

b. Fraction of initial inventory released per square centimeter of specimen surface area per second.

c. Concentrations of radionuclide in leachate samples were not determined.

d. Only the leachate corresponding to leaching interval number three was analyzed for ²⁴¹Pu. Leaching results are those determined for leaching interval number three.

e. Concentrations of acid in leachate samples were below detection limit.

f. Not all leachate samples were analyzed for this metal. CFR value was estimated by interpolating measured incremental release rates.

in deionized water. Examination of the data in the table indicates that among the radionuclides detected in the leachates, ^{63}Ni , ^{55}Fe , ^{90}Sr , and ^{137}Cs had the highest CFRs. Of these radionuclides, as previously discussed, only ^{63}Ni and ^{55}Fe were produced by neutron activation of the metal and released via the decontamination process. The CFRs of ^{55}Fe and ^{63}Ni are substantially higher (10^1 – 10^2) from the mixed-bed resin waste-form specimen than that observed for the cation resin and suggest that the release of ^{55}Fe and ^{63}Ni from the specimen may have been enhanced by the presence of chelating agents. This will be assessed in the discussion section. Other neutron activation products produced by the decontamination process (i.e., ^{54}Mn and ^{60}Co) have CFRs that are about a factor of 3 lower than ^{63}Ni .

The absolute and fractional release rates vary significantly for the samples leached in deionized water. The absolute release rate of ^{63}Ni was the highest by 1–2 orders of magnitude, whereas the fractional release rates of ^{63}Ni , ^{55}Fe , and ^{60}Co were quite similar. In contrast, the fractional release rate of ^{137}Cs was about 2 orders of magnitude higher than the other radionuclides. The wide differences in the fractional release rates are evaluated in the discussion section.

The leachability indexes of all radionuclides are well above the BTP requirement of greater than 6. The lowest leachability index is for ^{137}Cs (7.5). Of the activated metals removed from surfaces by the Citrox/AP/Citrox process, the lowest leachability index is 11.0 for ^{55}Fe .

The CFRs of the chelating agents and stable metals in deionized water are also shown in Table 13. The CFRs of the oxalic and citric acids are statistically the same and suggest that the leachability of the two chelating agents is very similar. Also, the leachability indexes for the two chelating agents are well above requirements in the "Technical Position on Waste Form" (Revision 1), with an average leachability index of 11.25. In contrast to the chelating agents, none of the stable metals were present in measurable amounts; consequently, leachability indexes for

the stable metals were calculated concentrations based on the detection limit. All of the leachability indexes for stable metals are higher than the BTP requirement.

Table 14 lists the leach test results for the Brunswick-1 mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with a pH of 10.4. Radionuclides that were removed by the decontamination process all had similar CFRs. All radionuclides had leachability indexes greater than the BTP standard with ^{55}Fe having the lowest (13.4) of the activation products that were measured.

The CFRs of the chelating agents were a factor of 5–10 times higher than the CFRs for radionuclides produced by neutron activation but similar to that of the fission product radionuclide, ^{90}Sr . However, both the absolute and fractional release rates of the chelating agents were considerably higher than the release rates of the activation product radionuclides, as indicated in Table 14. It should be noted that, similar to the sample leached in deionized water, the release rates vary significantly. These differences are evaluated in the discussion section. Also, the stable metal concentrations in the leach solutions were too low to calculate actual CFRs, release rates, and leachability indexes. However, the detection limit calculations that were performed indicated that all stable metals had leachability indexes greater than 6.0.

The leachability data for the Brunswick-1 mixed-bed resin samples leached in synthetic Barnwell ground water with pH 4.2, shown in Table 15, are very similar to the leachability data for the synthetic Barnwell water with pH 10.4 (Table 14) with several exceptions. The principal exceptions are that the ^{90}Sr releases are about a factor of 5 lower in the pH 4.2 Barnwell ground water. Leachability indexes are nearly the same in all cases and are above the BTP requirement. These data suggest that releases for some components (i.e., ^{90}Sr) may be pH dependant.

The leach test results for the Brunswick-1 mixed-bed resin waste-form specimen leached in Hanford ground water with pH 8.9 are shown

in Table 16. Based on the CFRs, the principal decontamination-process products released were ^{60}Co , ^{55}Fe , and ^{63}Ni . Although the CFRs of these radionuclides are similar, the CFR of ^{60}Co is about an order of magnitude higher, indicating significantly different release mechanisms for these radionuclides. The absolute and fractional release rates also vary significantly, with the fractional release rate of ^{63}Ni about 3 orders of magnitude higher than the fractional release rates of ^{60}Co and ^{55}Fe . In all cases, the leachability indexes were above 6.0. Also, similar to the other mixed-bed resin samples, the chelating agent releases were measurable and similar to the deionized water data. Leachability indexes that were calculated by using detection limit concentrations indicate that all were greater than 6.0.

Leaching results for the waste-form specimen leached in seawater are listed in Table 17. Only the concentrations for ^{60}Co , citric acid, and chromium were measurable. The concentrations of ^{55}Fe and ^{63}Ni were not measured because of the high concentrations of other elements, which made it difficult to separate and perform an accurate analysis of the concentrations of these elements in the leachates. The CFR of ^{60}Co is about a factor of 3 lower than the deionized water sample and suggests that the high ion strength of the seawater leachant may have retarded releases from the specimen.

As shown in Table 17, the leachability index for chromium was measurable, although there were insufficient data to calculate CFRs and leachability indexes for the other elements. Leachability indexes were calculated using the detection limit concentrations, which indicated that the leachability of all stable metals and the chromium in particular were well within the guidelines set by the NRC.

Leachant Effects on Radionuclides, Chelating Agents, and Stable Metals from Brunswick-1 Mixed-Bed Resin Waste-Form Specimens. Comparisons of the effects of different leachants on the CFRs, average release rates, and leachability indexes for principal radionuclides, chelating agents, and stable metals for Brunswick-1 mixed-bed waste-form

specimens are presented in the following sections. The radionuclides evaluated were ^{60}Co , ^{63}Ni , and ^{55}Fe . Comparisons for other radionuclides are summarized at the end of this section along with a summary of the long-term leaching results.

Leachant Effects on the Release of Radionuclides from Brunswick-1 Mixed-Bed Resin Waste-Form Specimens—

Leachant effects on the release of radionuclides are discussed through comparisons of the CFRs, absolute and fractional release rates, and leachability indexes for the radionuclides measured. Comparisons of the CFRs from the Brunswick-1 mixed-bed resin waste-form specimens for the principal radionuclides released by the decontamination process are shown in Figures 28 through 30 for ^{60}Co , ^{63}Ni , and ^{55}Fe . Also, the results for ^{137}Cs are shown in Figure 31 for comparison purposes. CFRs of ^{60}Co in the different leachants are plotted as a function of the square root of leaching time in Figure 28. The results presented in Figure 28 show that only very small fractions ($\leq 1.6 \times 10^{-3}$) of the inventories of ^{60}Co were leached from the waste-form specimens. The samples leached in deionized water and the Hanford ground water with pH 8.9 had the highest CFRs of ^{60}Co .

Examination of Figure 28 indicates that the sample leached in deionized water had both initial and continued high CFRs of ^{60}Co . During the initial phase of the test (<5 days), the CFRs from the samples leached in leachants other than deionized water began to stabilize on a diffusion-driven release as indicated by the linearity of the CFR plots. However, a significant increase in the release from the sample leached in seawater occurred between 46 and 90 days when the CFR increased by about a factor of 4. Why this occurred is not known because the sample leached in seawater split into two parts about 10 hours into the leaching period. No further obvious degradation occurred.

All samples except the sample leached in seawater decomposed within a few days of the beginning of the leach period; however, as

Figure 28. Cumulative fraction release of ^{60}Co from five Brunswick Unit 1 mixed-bed resin waste-form specimens.

Figure 29. Cumulative fraction release of ^{63}Ni from five Brunswick Unit 1 mixed-bed resin waste-form specimens.

Figure 30. Cumulative fraction release of ^{55}Fe from five Brunswick Unit 1 mixed-bed resin waste-form specimens.

indicated in Figure 28, the ^{60}Co releases varied significantly for different leachants. The fact that the leachability of the ground water samples stabilized so quickly, similar to the seawater sample, suggest that much of the release was driven by the formation of a concentration gradient at the surface of the debris pile that would tend to retard the release of ^{60}Co from the freshly exposed surfaces. Mechanisms that would tend to retard the CFR from waste-form specimens in natural ground waters (which increase the CFR in deionized water) are presented in the discussion section.

A comparison of the CFRs of ^{63}Ni for four Brunswick-1 mixed-bed resin waste-form specimens is shown in Figure 29. Examination of Figure 29 indicates that the CFR of ^{63}Ni from the sample leached in deionized water was at least a factor of 10 greater than the CFR of ^{63}Ni from the samples leached in other leachants. Also, the CFR of the sample leached in deionized water did not stabilize completely into a diffusion-driven release until approximately 50 days after leaching began. For ^{63}Ni , deionized water is the most

aggressive leachant, and these results suggest that the release from the decomposed specimen is diffusion driven. However, the long period (50 days) required to reach a stable diffusion-driven release suggest that the formation of a concentration gradient at the surface of the debris bed inhibited a release of ^{63}Ni through surface effects.

A comparison of the CFRs of ^{63}Ni and ^{60}Co indicates similarities in the behavior of the two radionuclides. The CFR plots are similar for both radionuclides, with deionized water being the most aggressive leachant. The CFR of ^{63}Ni in deionized water is, however, about a factor of 3 higher than the CFR of ^{60}Co . Also, there is a difference in the period of time required for the CFRs to stabilize. For ^{60}Co , about 16 days was required in contrast to the 49 days required for the concentration of ^{63}Ni to stabilize.

Figure 30 shows the comparison of the CFRs of ^{55}Fe for the Brunswick-1 mixed-bed resin waste-form specimen. The CFR plots for ^{55}Fe are similar to the plots for ^{63}Ni ; however, about twice as much was released. For this radionuclide, the

highest CFR is the result from the sample leached in deionized water. The pattern of the CFR of ^{55}Fe in deionized water is different from the other radionuclides discussed, with much of the release coming within the first four days. However, the length of time required to reach a diffusion-driven release is similar to ^{60}Co and not ^{63}Ni . These data suggest that the CFRs of various radionuclides from the Brunswick-1 mixed-bed resin waste-form specimens follow a similar release pattern (i.e., deionized water is the most aggressive leachant); however, the absolute magnitude of the release varies by radionuclide, and the period required to reach a diffusion-driven release is also radionuclide-specific.

The CFRs of other radionuclides were not plotted except for those shown in Appendix E; however, examinations of the data indicate radionuclide-specific differences that apparently controlled the quantity released and the time during the leaching period when the release occurred. An examination of the ^{137}Cs plots shown in Figure 31 indicates that all leachants generally behaved similarly, with no particular leachant causing substantially greater releases. However, the releases of ^{137}Cs from the mixed-bed resin waste-form specimens appear to be higher in the acidic leachants than in the alkaline leachants. Considering the estimated uncertainty for ^{137}Cs CFRs previously given (i.e., $\pm 20\%$ at 90 days), CFRs of ^{137}Cs in the neutral and acidic leachants were statistically the same after 200 days, but CFRs in the two acidic leachants were, at a minimum, between 52% and 68% higher than CFRs of ^{137}Cs in the two alkaline leachants. These data suggest radionuclide and leachant-specific differences in the leachability of ^{137}Cs and that the fission-produced radionuclides appear to behave differently from those produced by neutron activation.

Comparison of the CFRs of the principal radionuclides indicates several trends to be evaluated in the discussion section. Observations to be discussed include the fact that deionized water is the most aggressive leachant for ^{54}Mn , ^{55}Fe , ^{60}Co , ^{63}Ni , and ^{90}Sr , whereas for some fission product radionuclides, differences in leachant composi-

tion do not significantly affect the CFR. The CFR of ^{137}Cs for the decomposed waste-form specimens is statistically very similar to that measured for the relatively intact specimen leached in seawater although the time required for the sample leached in seawater, to reach a diffusion-driven release was longer.

The CFRs of most radionuclides from the mixed-bed resin waste-form specimens were generally well below 1%. However, two radionuclides, ^{90}Sr and ^{137}Cs , had CFRs of 1% or higher after 90 days, with values of 23% and 26%, respectively. The maximum release of 26% of the initial inventory ^{137}Cs was for the specimen leached in seawater.

A comparison of the absolute release rates from the Brunswick-1 mixed-bed resin waste-form specimen indicates wide variations in the release rates of different radionuclides. Typically, the absolute rates vary over 1–2 orders of magnitude for different radionuclides in the same leachate. In contrast to the radionuclides produced by decontamination (e.g., ^{63}Ni , ^{55}Fe , and ^{60}Co), the absolute and fractional release rates of ^{137}Cs are similar for all leachates. These data are assessed further in the discussion section.

Fractional release rates from the Brunswick-1 mixed-bed resin waste-form specimens are summarized for the 90-day leaching period in Tables 13 through 17. The radionuclides (i.e., ^{60}Co , ^{63}Ni , and ^{55}Fe) produced by the decontamination process are discussed along with the release rates of ^{137}Cs , which are presented for comparison purposes. Figure 32 shows the fractional release rates of ^{60}Co for all five Brunswick-1 mixed-bed waste-form specimens. The release rates of ^{60}Co from all samples decreased significantly during the first five days and then generally continued to decline when longer leaching intervals were used. Releases occurring during the initial fast-release period (i.e., 0 to 5 days) accounted for 85% of the total quantity of ^{60}Co released to the deionized water leachant at the end of 90 days, with correspondingly lesser totals for the samples leached in ground waters (i.e., 75%–93%). An assessment

Figure 31. Cumulative fraction release of ^{137}Cs from five Brunswick Unit 1 mixed-bed resin waste-form specimens.

Figure 32. Fractional release rate of ^{60}Co from five Brunswick Unit 1 cation resin waste-form specimens.

of the uncertainties associated with the data indicates that statistically, with few exceptions, the releases rates were the same for all leachants after the initial release.

The fractional release rates of ^{63}Ni and ^{55}Fe are shown in Figures 33 and 34. These data are similar to those shown for ^{60}Co (Figure 32) and follow the same trend as those indicated for ^{60}Co , where most of the release occurred within the first five days. However, the fractional release rates of both ^{55}Fe and ^{63}Ni in the deionized water leachant continued to be higher throughout most of the 90-day leach test. These data suggest that the leachability of ^{55}Fe and ^{63}Ni are similar but different than that of ^{60}Co .

In contrast to the radionuclides produced through activation, the primary fission product radionuclides (i.e., ^{137}Cs , ^{90}Sr , and ^{125}Sb) had similar fractional release rates for all leachants. The ^{137}Cs release rate data, which are representative of the behavior of the other fission product radionuclides, are shown in Figure 35. These fractional release rates are all quite similar with little or no spiking in the early release period as was indicated in the release rate plots for ^{60}Co , ^{55}Fe , and ^{63}Ni . As indicated in Figure 35, the relatively intact waste-form specimen that was leached in seawater had the highest fractional release rate in the latter part of the leaching test. These data suggest that the diffusion rate out of the loose debris is not substantially faster than the release from the partially intact waste form. Mechanisms for the retention of the radionuclides are evaluated in the discussion section.

Leachability indexes for all radionuclides for the 90-day leach period for the Brunswick-1 mixed-bed resin waste-form specimens are presented in Tables 13-17. The leachability indexes of all radionuclides ranged from a low of 10.1 for ^{137}Cs in Barnwell ground water with pH 10.4 to a high of 16.7 for ^{60}Co in leachants with pH 4.2 and 8.9. All leachability indexes were substantially greater than 6. The leachability indexes of ^{54}Mn and ^{60}Co in deionized water were lower than leachability indexes of these radionuclides in other leachants, whereas the leachability indexes

of ^{55}Fe , ^{63}Ni , ^{90}Sr , and ^{137}Cs were similar for all leachants.

Leachant Effects on the Release of Chelating Agents from Brunswick-1 Mixed-Bed Resin Waste-Form Specimens—Leachant effects on the release of chelating agents are discussed through comparisons of CFRs, average release rates, and leachability indexes for the two chelating agents, citric and oxalic acid. The CFRs for citric acid and oxalic acid in the five leachants are plotted in Figures 36 and 37, respectively. Examination of these figures indicates that, statistically, the CFRs for all leachants and both chelating agents were similar (i.e., the uncertainty associated with these data is 150 to 200%). These data indicate that there was little or no leachant effects on the CFRs of the chelating agents. It should be noted that, as previously discussed, the seawater leachates could not be analyzed for oxalic acid, but that based on the behavior of citric acid, the CFR should be similar to the other leachants.

The period of time before the chelating-agent releases from the mixed-bed waste-form specimen stabilized in a diffusion-driven release (about 5 days) was similar to that determined for ^{137}Cs . The chelating agent CFRs are similar to the fission-product radionuclide CFRs (i.e., ^{137}Cs and ^{125}Sb), where the effects of all leachants were similar and in contrast to the ^{63}Ni , ^{55}Fe , and ^{60}Co CFRs, in which deionized water was the most aggressive leachant.

The fractional release rates of citric and oxalic acids are shown in Figures 38 and 39, respectively. In both cases, the pattern of the releases is about the same, with an initial large release followed by a slower diffusion-driven release after five days. In the case of citric acid, the release rates from the specimen leached in seawater were generally about the same as the release rates from the other four waste-form specimens, indicating that citric acid retention in the crumbled specimens was similar to the relatively intact specimen that was leached in seawater. The seawater leachates could not be analyzed for oxalic acid because of interferences from constituents of the synthetic leachant as discussed previously.

Figure 33. Fractional release rate of ^{63}Ni from five Brunswick Unit 1 cation resin waste-form specimens.

Figure 34. Fractional release rate of ^{55}Fe from five Brunswick Unit 1 cation resin waste-form specimens.

Figure 35. Fractional release rate of ^{137}Cs from five Brunswick Unit 1 cation resin waste-form specimens.

Figure 36. Cumulative fraction release of citric acid from five Brunswick Unit 1 mixed-bed resin waste-form specimens.

Figure 37. Cumulative fraction release of oxalic acid from five Brunswick Unit 1 mixed-bed resin waste-form specimens.

Figure 38. Fractional release rate of citric acid from five Brunswick Unit 1 mixed-bed resin waste-form specimens.

Figure 39. Fractional release rate of oxalic acid from five Brunswick Unit 1 mixed-bed resin waste-form specimens.

Leachability indexes for the chelating agents, citric and oxalic acid, are presented in Tables 13–17. The leachability indexes for oxalic acid ranged from 10.9 to 11.0 for all leachates except seawater, which was not measurable. For citric acid, the range of leachability indexes was 11.4 to 11.6 for all leachates except for the Barnwell ground water with pH 4.2, which had a lower leachability index of 10.9. As previously noted, the leachability indexes of both chelating agents are effectively the same due to the large uncertainties associated with the data.

Leachant Effects on the Release of Stable Metals from Brunswick-1 Mixed-Bed Resin Waste-Form Specimens—The CFRs and average release rates for the stable metals were not plotted because all data except the chromium results for seawater were below the detection limits of the instrument used to perform the measurements. An assessment of the results in Appendix G, Tables G-6 through G-10, indicate no obvious trends associated with the few data points that are present.

The leachability indexes of chromium, iron, cobalt, and nickel for the Brunswick Unit 1 mixed-bed resin waste-form specimens are summarized in Table 18. The leachability indexes of the four metals measured ranged from >6.5 for nickel in the Barnwell ground water with pH 4.2 to >11.9 for chromium in deionized water. The only measured leachability index was for chromium in seawater with pH 6.4. These data indicate relatively low leachability for the stable metals because all results were based on instrument detection limits except for the leachability index for chromium, which was well above the BTP requirement.

Brunswick-1 Mixed-Bed Resin Long-Term Leaching Results. After the initial 90-day leaching period, leaching was continued through 201 days except for the sample leached in deionized water, which was continued for a total of 388 days. Results for the various radioisotopes are shown in Figures 18 through 25 and are tabulated in Appendix G. The results generally followed the trends observed during the

Table 18. Summary of leachability indexes of stable metals for Brunswick Unit 1 mixed-bed resin waste-form specimens^a

<u>Leachant pH</u>	<u>Chromium</u>	<u>Iron</u>	<u>Cobalt</u>	<u>Nickel</u>
4.2	>10.5	>8.3	>8.0	>6.5
6.4	9.7 ± 0.1	>9.0	>8.3	>7.2
7.0	>11.9	>10.1	>9.2	>8.1
8.9	>10.7	>8.8	>7.9	>6.7
10.4	>10.6	>8.8	>7.8	>6.6

a. Results presented in the table are for the first 90 days of leaching.

90-day leaching period. However, some long-term effects occurred such as the increase in the ⁶⁰Co release rates measured after 170 days of leaching (see Figure 28). Between 170 and 200 days of leaching, portions of several specimens that had remained in the support nets fell to the bottoms of the leaching containers and may have resulted in an increase in the activity measured.

Leach-Test Results for James A. FitzPatrick Station Waste-Form Specimens

This section presents the results of leaching tests performed on seven mixed-bed resin waste-form specimens collected from the James A. FitzPatrick Station. The following results are discussed: (a) the physical stability of the waste-form specimens during leaching, (b) the final pH and conductivity of leachates, and (c) the cumulative fraction releases, incremental fraction release rates, and leachability indexes of radionuclides, metals, and chelating agents.

Physical Stability of Waste-Form Specimens During Leaching. The physical stability of the waste-form specimens from James A. FitzPatrick varied significantly as many of the

specimens deteriorated within several hours after being placed in the different leachants. Table 19 summarizes the degradation of each waste-form sample that occurred during leaching.

Examination of Table 19 indicates that the only specimens that maintained their gross physical shape during the leaching period were those leached in seawater, deionized water, and Barnwell ground waters. However, the samples leached in these leachants probably all lost compressive strength during the initial part of the test due to cracking. Examples of representative samples at the end of 90 days are shown in Figures 40 through 43.

The results in Table 19 suggest that although the degradation of all samples was severe, baking early in the curing period resulted in additional degradation of the samples during leaching. The effects of higher curing temperatures and the extent to which they simulate the hydration exotherm are assessed in the discussion section.

A photograph of an unbaked waste-form specimen that was leached in deionized water for 90 days is shown in Figure 40. As shown in the photograph, the specimen seriously deteriorated during the test. Figure 41 is a photograph of an unbaked waste-form specimen after leaching in

Table 19. Physical stability of the James A. FitzPatrick waste forms

Waste Form	<2 Hours	8 Hours	>8 Hours	90 days
Ambient temperature cure				
Deionized water	Cracking ^a	—	Major cracks ^b	Intact ^c
Seawater (pH 6.4)	Cracking ^a	—	Major cracks ^{b,d}	Intact ^c
Hanford (pH 8.9)	Cracking ^a	—	Major cracks ^b	Decomposition ^e
Barnwell (pH 4.2)	Cracking ^a	—	Major cracks ^b	Intact ^c
Barnwell (pH 10.4)	Cracking ^a	—	Major cracks ^b	Intact ^c
Baked during curing				
Deionized water	Severe cracks ^f	—	Initial decomposition ^g	Rubble
Barnwell (pH 4.2)	Severe cracks ^f	—	Initial decomposition ^g	Rubble

a. Relatively large cracks appeared on sample within two hours, and within 7 hours, numerous cracks covered the surface of sample.

b. Expansion of the cracks continued to where some of the cracks had grown to about 6 mm (0.25 in.) in depth. After 48 hours, major cracks traversed the body of sample, and some debris had slumped to the bottom of the net.

c. Remained primarily intact with only small amounts of material falling off the waste form. Less than 30 grams fell off of any sample.

d. After 24 hours of leaching, one major crack had formed in the body of the specimen leached in seawater, and stalagmites grew from the upper surface of the specimen. After 48 hours, several small additional cracks occurred, but only a negligible quantity of material flaked off the sample.

e. Approximately one third of the sample had decomposed by the end of the 90-day leach period.

f. For the samples that had been baked for four hours during curing, severe cracking occurred within two hours, and for the sample leached in pH 4.2, general disintegration had begun, and after 7 hours, the sample had slumped into the net holding the sample.

g. After two days, large cracks traversed the surface of the specimen leached in the pH 4.2 leachant, and 15–20 grams had sloughed off the sample. Both samples had crumbled to loose rubble at the end of the 90-day period.

Figure 40. FitzPatrick waste-form specimen after leaching in deionized water for 90 days.

Figure 41. FitzPatrick waste-form specimen after leaching in synthetic seawater for 90 days.

Figure 42. FitzPatrick waste-form specimen, that was baked during initial curing, after leaching in deionized water for 90 days.

Figure 43. FitzPatrick waste-form specimen, that was baked during initial curing, after leaching for 90 days in synthetic Barnwell ground water with pH 4.2.

seawater for 90 days. The specimen remained intact, and as was the case with the Brunswick Unit 1 waste-form specimens that were leached in seawater; the surface of the specimen was covered with mineral deposits. The degradation of the two waste-form specimens that were baked during initial curing were much more pronounced than those cured at ambient temperature. The surfaces of the baked samples buckled soon after they were immersed in their respective leachants. Both samples, which were leached in deionized water and Barnwell ground water with pH 4.2, completely crumbled into loose rubble by the end of 90 days. Photographs of the two baked waste-form specimens showing their conditions after 90 days of leaching are presented in Figures 42 and 43, respectively.

FitzPatrick Mixed-Bed Resin Leachate pH and Conductivity. To assess the effects of pH and conductivity on the leachability of the waste-form specimens, pH and conductivity measurements were made on the James A. FitzPatrick mixed-bed resin leach solutions at the end of each leaching period. The leachants are identified as Barnwell ground water pH 10.4 (BGW pH 10.4), Deionized water pH 7.0 (DW), Hanford ground water pH 8.9 (HGW), Barnwell ground water pH 4.2 (BGW pH 4.2) and seawater (SW). The samples that were leached after having been baked for 4 h at 49°C are identified as deionized water pH 7.0 (B-DW), and Barnwell ground water pH 4.2 (B-BGW).

The pH and conductivity of the FitzPatrick waste-form leachates are shown in Figures 44 and 45, respectively. Conductivities shown in Figure 45 are expressed in units of mmho/cm at 25°C. The conductivities of the seawater leachate samples were above the range (i.e., 20 mmho/cm) of the conductivity meter used, so conductivities of the seawater leachates were not determined.

Examination of Figure 44 indicates that the leachate pH stayed very constant for all leachates except for the seawater leachates. During the initial leaching periods, the pH ranged down to pH 9.4 for the Barnwell ground water pH 4.2. In contrast, the pH of the deionized water and

ground water leachates remained between 10.8 to 11.8.

During the first two days of leaching, when leachates were changed out after elapsed times of 2, 7, 24, and 48 h, the final pH of the deionized water and ground water leachates gradually increased, reaching maxima that ranged between 12.1 and 12.4. The pH values remained in the general range from 12.2 to 12.5 thereafter. In the case of the seawater leachant, leachate pH increased from 9.2 after the initial 2 h of leaching to a maximum of 9.9 after 48 h of leaching.

Conductivities of the deionized and ground water leachates shown in Figure 45 ranged from 0.7 mmho/cm for leachant with pH 10.4 to 3.5 mmho/cm for deionized water at the end of the initial 2-h leaching period. Leachate conductivities rose to maxima ranging between 2.8 and 5.1 mmho/cm after 2 days, and after 4 days, they decreased slightly to minima ranging between 2.4 and 4.8 mmho/cm. When the leaching periods were increased to 13 days, the conductivities increased gradually to between 7.3 and 8.1 mmho/cm after either 46 or 98 days of leaching. During the long-term leaching of the two specimens leached in deionized water, leachate conductivities decreased to minimum values of 5.6 and 6.0 mmho/cm for the baked and unbaked waste-form specimens, respectively. These data suggest that the chemistry of the waste-form specimen controlled the pH and conductivity of the leachates, and that the effects of leachant chemistry are relatively insignificant.

Releases of Radionuclides, Chelating Agents, and Stable Metals from FitzPatrick Mixed-Bed Resin Waste-Form Specimens. This section presents the release of radionuclides, chelating agents, and stable metals from FitzPatrick mixed-bed waste-form specimens. The results are presented as CFRs, average release rates, and leachability indexes for the seven samples that were leached. The concentrations of radionuclides and stable metals on which the previously mentioned values are based are shown in Appendix J, Tables J-11 through J-17. Also, the concentrations of the chelating agent picolinic acid are presented in

Figure 44. Leachate pH for seven FitzPatrick ion-exchange resin waste-form specimens.

Figure 45. Leachate conductivity for six FitzPatrick ion-exchange resin waste-form specimens.

Appendix K, Table K-2. It should be noted that only selected leachate samples were analyzed for ^{55}Fe , ^{63}Ni , ^{90}Sr , and the stable metals. Measurements of the concentrations of these elements for the seawater samples were not possible due to chemical separation problems. The high concentrations of ionic constituents in the seawater leachant made the results of the ^{55}Fe and ^{63}Ni analyses difficult to reproduce and resulted in large uncertainties in the data.

Tables 20 through 26 show the CFRs, the absolute and fractional release rates, the effective diffusivities, and leachability indexes for the radionuclides, chelating agents, and stable metals for the 90-day BTP leach test. The tables present results for each of the seven samples that were leached.

Table 20 contains the summary of the CFRs, absolute and fractional release rates, and leachability indexes for the FitzPatrick mixed-bed resin waste-form specimen that was leached in deionized water. Examination of the data indicates that ^{63}Ni , ^{60}Co , and ^{137}Cs had the highest measurable CFRs. Of these radionuclides, only ^{63}Ni and ^{60}Co are of importance in this study because they were produced through neutron activation of the metal and released via the decontamination process. Also, as noted in Table 6, ^{137}Cs was present as less than 1% of total radionuclides in the waste-form specimens. It is important to note that ^{241}Pu was measured for one interval, and that the CFR was determined to be significantly lower than the CFR for the other radionuclides measured (10^4 lower than ^{60}Co). For that reason, the ^{241}Pu data were not plotted.

The fractional release rate of ^{63}Ni is considerably higher (a factor of 4) than the other decontaminated radionuclides. The leachability indexes are all well above the BTP requirement of 6.0. The lowest leachability index is for ^{134}Cs , a fission product, which is also above the BTP standard at 6.6. Of the activated metals removed from surfaces by the Citrox/AP/Citrox process, the lowest leachability index is for ^{63}Ni at 8.9. It should be noted that the absolute release rates vary over four orders of magnitude and that the

fractional release rates vary over three orders of magnitude. These data indicate both radionuclide- and leachant-specific differences in release rates.

The CFRs of picolinic acid and the stable metals in deionized water are also shown in Table 20. The CFR of picolinic acid is higher than most of the activation products and similar to that of ^{137}Cs .

Table 21 lists the leach-test results for the FitzPatrick mixed-bed resin waste-form specimen that was leached in synthetic Barnwell ground water with pH 10.4. The activation radionuclide with the highest CFR that was removed by the decontamination process was ^{63}Ni . The fractional release rate for this radionuclide was similar to that measured for the sample leached in deionized water. All radionuclides had leachability indexes greater than the BTP standard. ^{63}Ni had the lowest leachability index (i.e., 9.0) of the activation products measured.

Picolinic acid had the highest CFR of the constituents measured. Also, the absolute and fractional release rates of this chelating agent were the highest of the constituents measured. The leachability index of picolinic acid (i.e., 7.2) was substantially less than the leachability indexes of the activation products measured.

The stable metal concentrations in the leach solutions were too low for all elements except nickel to calculate actual CFRs, release rates, or leachability indexes. The leachability index for nickel (9.5) was nearly the same as ^{63}Ni . The leachability index calculations performed for the other elements measured indicate that their leachability indexes were substantially greater than those measured for nickel.

The leach-test results for the FitzPatrick mixed-bed resin samples that were leached in synthetic Barnwell ground water with pH 4.2, as shown in Table 22, are very similar to the results for the Barnwell water with pH 10.4 (Table 21) with several exceptions. Principally, the CFR for picolinic acid in the pH 4.2 Barnwell ground

Table 20. Leach test results for James A. FitzPatrick mixed-bed resin waste-form specimen leached in deionized water^a

Nuclide	CFR	Release Rate		Average Effective Diffusivity (cm ² /s)	Leachability Index
		($\mu\text{Ci}/\text{cm}^2\cdot\text{s}$)	(F/cm ² ·s) ^b		
⁵⁴ Mn	5.6 (–4)	1.0 ± 0.5 (–9)	6 ± 3 (–12)	3 ± 1 (–13)	13.3 ± 0.3
⁵⁵ Fe	6.1 (–3) ^c	7 ± 5 (–10)	7 ± 5 (–11)	3 ± 2 (–11)	11.6 ± 0.8
⁵⁸ Co	1.2 (–2)	9 ± 2 (–9)	5 ± 1 (–11)	2.6 ± 0.7 (–11)	10.8 ± 0.2
⁶⁰ Co	1.7 (–2)	5 ± 1 (–8)	7 ± 2 (–11)	5 ± 1 (–11)	10.5 ± 0.2
⁶³ Ni	9.2 (–2) ^c	1.3 ± 0.4 (–8)	6 ± 1 (–10)	4 ± 1 (–9)	8.9 ± 0.3
⁶⁵ Zn	2.3 (–3)	4 ± 2 (–10)	1.0 ± 0.5 (–11)	1.2 ± 0.4 (–12)	12.3 ± 0.2
⁹⁰ Sr	— ^d	— ^d	— ^d	— ^d	— ^d
¹²⁵ Sb	<7.7 (–3)	<7.9 (–11)	<5.1 (–11)	<3.6 (–11)	>11.0
¹³⁴ Cs	7.3 (–1)	8 ± 3 (–9)	6 ± 2 (–9)	3.6 ± 0.7 (–7)	6.6 ± 0.2
¹³⁷ Cs	6.4 (–1)	1.5 ± 0.5 (–8)	5 ± 2 (–9)	1.5 ± 0.5 (–7)	7.1 ± 0.2
²⁴¹ Pu	— ^e	6.7 (–12)	6.9 (–13)	2.2 (–15)	14.7
Acid or Metal		($\mu\text{g}/\text{cm}^2\cdot\text{s}$)			
Picolinic acid	5.4 (–1)	8 ± 3 (–3)	3 ± 1 (–9)	1.4 ± 0.8 (–7)	7.5 ± 0.3
Chromium	<6.6 (–3) ^c	<1.6 (–6)	<5.7 (–11)	<2.4 (–11)	>11.2
Iron	<3.3 (–3) ^c	<1.0 (–5)	<2.6 (–11)	<5.4 (–12)	>12.0
Cobalt	<2.5 (–2) ^c	<8.0 (–6)	<2.2 (–10)	<3.5 (–10)	>10.0
Nickel	5.0 (–2) ^c	5 ± 2 (–6)	3 ± 1 (–10)	1.1 ± 0.5 (–9)	9.4 ± 0.4

a. Results are for only the first 90 days of leaching.

b. Fraction of initial inventory released per square centimeter of specimen surface area per second.

c. Not all leachate samples were analyzed for this radionuclide or metal. CFR value was estimated by interpolating measured incremental release rates.

d. Concentrations of radionuclide in leachate samples were not determined.

e. Only the leachate corresponding to leaching interval number three was analyzed for ²⁴¹Pu. Leaching results are those determined for leaching interval number three.

Table 21. Leach test results for James A. FitzPatrick mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with pH 10.4^a

Nuclide	CFR	Release Rate		Average Effective Diffusivity (cm ² /s)	Leachability Index
		($\mu\text{Ci}/\text{cm}^2\cdot\text{s}$)	(F/cm ² ·s) ^b		
⁵⁴ Mn	5.5 (-4)	5 ± 2 (-10)	3 ± 1 (-12)	5 ± 1 (-14)	13.6 ± 0.2
⁵⁵ Fe	7.1 (-3) ^c	6 ± 3 (-10)	6 ± 4 (-11)	2 ± 1 (-11)	11.6 ± 0.9
⁵⁸ Co	1.2 (-2)	7 ± 2 (-9)	3.6 ± 0.9 (-11)	1.6 ± 0.3 (-11)	11.0 ± 0.2
⁶⁰ Co	1.7 (-2)	3.6 ± 0.9 (-8)	5 ± 1 (-11)	3.4 ± 0.7 (-11)	10.6 ± 0.2
⁶³ Ni	1.0 (-1) ^c	2 ± 1 (-8)	8 ± 5 (-10)	5 ± 3 (-9)	9.0 ± 0.5
⁶⁵ Zn	5.9 (-3)	6 ± 2 (-10)	1.5 ± 0.4 (-11)	3.0 ± 0.8 (-12)	11.7 ± 0.2
⁹⁰ Sr	— ^d	— ^d	— ^d	— ^d	— ^d
¹²⁵ Sb	<7.5 (-3)	<7.2 (-11)	<4.8 (-11)	<1.8 (-11)	>11.0
¹³⁴ Cs	6.2 (-1)	6 ± 2 (-9)	4 ± 1 (-9)	1.8 ± 0.3 (-7)	6.9 ± 0.2
¹³⁷ Cs	5.5 (-1)	1.0 ± 0.3 (-8)	4 ± 1 (-9)	1.5 ± 0.3 (-7)	7.0 ± 0.2
²⁴¹ Pu	— ^e	9.3 (-13)	9.8 (-14)	4.4 (-17)	16.4
Acid or Metal		(μg/cm ² ·s)			
Picolinic acid	7.5 (-1)	9 ± 3 (-3)	3 ± 1 (-9)	1.4 ± 0.4 (-7)	7.2 ± 0.3
Chromium	<6.7 (-3) ^c	<1.6 (-6)	<5.8 (-11)	<2.5 (-11)	>11.2
Iron	<3.3 (-3) ^c	<1.1 (-5)	<3.2 (-11)	<6.0 (-12)	>11.9
Cobalt	<2.6 (-2) ^c	<8.0 (-6)	<2.2 (-10)	<3.6 (-10)	>10.0
Nickel	5.0 (-2) ^c	6 ± 4 (-6)	4 ± 2 (-10)	1.0 ± 0.4 (-9)	9.5 ± 0.5

a. Results are for only the first 90 days of leaching.

b. Fraction of initial inventory released per square centimeter of specimen surface area per second.

c. Not all leachate samples were analyzed for this radionuclide or metal. CFR value was estimated by interpolating measured incremental release rates.

d. Concentrations of radionuclide in leachate samples were not determined.

e. Only the leachate corresponding to leaching interval number three was analyzed for ²⁴¹Pu. Leaching results are those determined for leaching interval number three.

Table 22. Leach test results for James A. FitzPatrick mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with pH 4.2^a

Nuclide	CFR	Release Rate		Average Effective Diffusivity (cm ² /s)	Leachability Index
		($\mu\text{Ci}/\text{cm}^2\cdot\text{s}$)	(F/cm ² ·s) ^b		
⁵⁴ Mn	7.2 (-4)	2 ± 1 (-9)	1.3 ± 0.8 (-11)	8 ± 7 (-13)	13.4 ± 0.3
⁵⁵ Fe	— ^c	— ^c	— ^c	— ^c	— ^c
⁵⁸ Co	1.2 (-2)	1.0 ± 0.3 (-8)	5 ± 2 (-11)	2.2 ± 0.5 (-11)	10.8 ± 0.1
⁶⁰ Co	1.8 (-2)	5 ± 2 (-8)	8 ± 3 (-11)	4.6 ± 0.9 (-11)	10.5 ± 0.1
⁶³ Ni	8.7 (-2) ^d	1.3 ± 0.5 (-8)	5 ± 2 (-10)	4 ± 2 (-9)	9.2 ± 0.6
⁶⁵ Zn	5.2 (-3)	1.3 ± 0.6 (-9)	3 ± 2 (-11)	4 ± 2 (-12)	11.6 ± 0.1
⁹⁰ Sr	— ^c	— ^c	— ^c	— ^c	— ^c
¹²⁵ Sb	<7.5 (-3)	<9.0 (-11)	<5.9 (-11)	<2.3 (-11)	>11.0
¹³⁴ Cs	6.9 (-1)	8 ± 2 (-9)	6 ± 2 (-9)	2.5 ± 0.4 (-7)	6.7 ± 0.1
¹³⁷ Cs	6.1 (-1)	1.4 ± 0.4 (-8)	5 ± 2 (-9)	1.9 ± 0.3 (-7)	6.8 ± 0.1
²⁴¹ Pu	— ^e	3.1 (-12)	3.2 (-13)	5.0 (-16)	15.3
Acid or Metal	(μg/cm ² ·s)				
Picolinic acid	4.2 (-1)	7 ± 2 (-3)	2.2 ± 0.7 (-9)	7 ± 3 (-8)	7.5 ± 0.2
Chromium	<6.7 (-3) ^d	<1.6 (-6)	<5.7 (-11)	<2.5 (-11)	>11.2
Iron	<5.1 (-3) ^d	<2.0 (-5)	<5.9 (-11)	<2.2 (-11)	>11.6
Cobalt	<2.5 (-2) ^d	<7.9 (-6)	<2.2 (-10)	<3.6 (-10)	>10.0
Nickel	4.8 (-2) ^d	4 ± 2 (-6)	2 ± 1 (-10)	7 ± 3 (-10)	9.5 ± 0.4

a. Results are for only the first 90 days of leaching.

b. Fraction of initial inventory released per square centimeter of specimen surface area per second.

c. Concentrations of radionuclide in leachate samples were not determined.

d. Not all leachate samples were analyzed for this radionuclide or metal. CFR value was estimated by interpolating measured incremental release rates.

e. Only the leachate corresponding to leaching interval number three was analyzed for ²⁴¹Pu. Leaching results are those determined for leaching interval number three.

Table 23. Leach test results for James A. FitzPatrick mixed-bed resin waste-form specimen leached in synthetic Hanford ground water with pH 8.9^a

Nuclide	CFR	Release Rate		Average Effective Diffusivity (cm ² /s)	Leachability Index
		($\mu\text{Ci}/\text{cm}^2\cdot\text{s}$)	(F/cm ² ·s) ^b		
⁵⁴ Mn	1.2 (-4)	3 ± 1 (-10)	1.5 ± 0.8 (-12)	1.0 ± 0.5 (-14)	14.6 ± 0.3
⁵⁵ Fe	6.3 (-3) ^c	5 ± 3 (-10)	5 ± 3 (-11)	2 ± 1 (-11)	11.3 ± 0.5
⁵⁸ Co	8.8 (-3)	6 ± 1 (-9)	3.0 ± 0.8 (-11)	1.0 ± 0.2 (-11)	11.1 ± 0.1
⁶⁰ Co	1.3 (-2)	3.0 ± 0.8 (-8)	4 ± 1 (-11)	2.0 ± 0.3 (-11)	10.8 ± 0.1
⁶³ Ni	9.8 (-2) ^c	1.5 ± 0.5 (-8)	6 ± 2 (-10)	4 ± 1 (-9)	8.9 ± 0.4
⁶⁵ Zn	1.6 (-3)	2.0 ± 0.9 (-10)	5 ± 2 (-12)	2.3 ± 0.7 (-13)	12.9 ± 0.2
⁹⁰ Sr	— ^d	— ^d	— ^d	— ^d	— ^d
¹²⁵ Sb	<5.6 (-3)	<6.9 (-11)	<4.4 (-11)	<1.8 (-11)	>11.2
¹³⁴ Cs	6.6 (-1)	6 ± 2 (-9)	4 ± 1 (-9)	1.8 ± 0.3 (-7)	6.9 ± 0.2
¹³⁷ Cs	5.9 (-1)	1.1 ± 0.3 (-8)	4 ± 1 (-9)	1.5 ± 0.3 (-7)	7.0 ± 0.2
²⁴¹ Pu	— ^e	5.4 (-13)	5.6 (-14)	1.5 (-17)	16.8
Acid or Metal		(μg/cm ² ·s)			
Picolinic acid	4.5 (-1)	4 ± 2 (-3)	1.2 ± 0.5 (-9)	9 ± 3 (-9)	8.3 ± 0.2
Chromium	<6.5 (-3) ^c	<1.6 (-6)	<5.5 (-11)	<2.4 (-11)	>11.2
Iron	<4.3 (-3) ^c	<1.2 (-5)	<3.6 (-11)	<1.2 (-11)	>11.5
Cobalt	<2.5 (-2) ^c	<7.8 (-6)	<2.1 (-10)	<3.5 (-10)	>10.0
Nickel	5.1 (-2) ^c	6 ± 5 (-6)	2 ± 1 (-10)	2 ± 1 (-10)	10.2 ± 0.4

a. Results are for only the first 90 days of leaching.

b. Fraction of initial inventory released per square centimeter of specimen surface area per second.

c. Not all leachate samples were analyzed for this radionuclide or metal. CFR value was estimated by interpolating measured incremental release rates.

d. Concentrations of radionuclide in leachate samples were not determined.

e. Only the leachate corresponding to leaching interval number three was analyzed for ²⁴¹Pu. Leaching results are those determined for leaching interval number three.

Table 24. Leach test results for James A. FitzPatrick mixed-bed resin waste-form specimen leached in synthetic seawater with pH 6.4^a

Nuclide	CFR	Release Rate		Average Effective Diffusivity (cm ² /s)	Leachability Index
		($\mu\text{Ci}/\text{cm}^2\cdot\text{s}$)	($\text{F}/\text{cm}^2\cdot\text{s}$) ^b		
⁵⁴ Mn	<4.5 (-5)	<8.8 (-11)	<4.9 (-13)	<1.0 (-15)	>15.4
⁵⁵ Fe	— ^c	— ^c	— ^c	— ^c	— ^c
⁵⁸ Co	1.3 (-2)	9 ± 3 (-9)	5 ± 2 (-11)	1.9 ± 0.4 (-11)	10.9 ± 0.1
⁶⁰ Co	2.0 (-2)	5 ± 2 (-8)	7 ± 2 (-11)	3.9 ± 0.7 (-11)	10.5 ± 0.1
⁶³ Ni	1.0 (-1) ^d	6 ± 3 (-9)	3 ± 1 (-10)	1.0 ± 0.4 (-9)	9.4 ± 0.5
⁶⁵ Zn	2.0 (-3)	1.9 ± 0.6 (-10)	4 ± 2 (-12)	2.7 ± 0.9 (-13)	12.9 ± 0.2
⁹⁰ Sr	— ^c	— ^c	— ^c	— ^c	— ^c
¹²⁵ Sb	<5.9 (-3)	<7.1 (-11)	<4.6 (-11)	<1.1 (-11)	>11.2
¹³⁴ Cs	8.4 (-1)	6 ± 3 (-9)	4 ± 2 (-9)	2.0 ± 0.5 (-7)	6.9 ± 0.1
¹³⁷ Cs	7.3 (-1)	1.1 ± 0.5 (-8)	4 ± 2 (-9)	1.4 ± 0.4 (-7)	7.0 ± 0.1
²⁴¹ Pu	— ^e	6.4 (-12)	6.6 (-13)	2.1 (-15)	14.7
Acid or Metal	(μg/cm ² ·s)				
Picolinic acid	1.1 (-1)	4 ± 1 (-3)	1.2 ± 0.4 (-9)	6 ± 1 (-9)	8.30 ± 0.08
Chromium	<6.6 (-3) ^d	<1.6 (-6)	<5.6 (-11)	<2.4 (-11)	>11.2
Iron	<4.1 (-3) ^d	<1.2 (-5)	<3.4 (-11)	<9.1 (-12)	>11.6
Cobalt	<2.5 (-2) ^d	<7.9 (-6)	<2.1 (-10)	<3.5 (-10)	>10.0
Nickel	<6.4 (-2) ^d	<5.0 (-6)	<3.0 (-10)	<8.9 (-10)	>9.2

a. Results are for only the first 90 days of leaching.

b. Fraction of initial inventory released per square centimeter of specimen surface area per second.

c. Concentrations of radionuclide in leachate samples were not determined.

d. Not all leachate samples were analyzed for this radionuclide or metal. CFR value was estimated by interpolating measured incremental release rates.

e. Only the leachate corresponding to leaching interval number three was analyzed for ²⁴¹Pu. Leaching results are those determined for leaching interval number three.

Table 25. Leach test results for baked James A. FitzPatrick mixed-bed resin waste-form specimen leached in deionized water^a

Nuclide	CFR	Release Rate		Average Effective Diffusivity (cm ² /s)	Leachability Index
		($\mu\text{Ci}/\text{cm}^2\cdot\text{s}$)	(F/cm ² ·s) ^b		
⁵⁴ Mn	1.1 (-3)	4 ± 2 (-9)	2 ± 1 (-11)	1.4 ± 0.8 (-12)	13.1 ± 0.5
⁵⁵ Fe	— ^c	— ^c	— ^c	— ^c	— ^c
⁵⁸ Co	1.5 (-2)	1.8 ± 0.7 (-8)	1.0 ± 0.4 (-10)	4 ± 1 (-11)	10.6 ± 0.1
⁶⁰ Co	2.2 (-2)	1.0 ± 0.4 (-7)	1.4 ± 0.6 (-10)	8 ± 2 (-11)	10.3 ± 0.1
⁶³ Ni	1.1 (-1) ^d	3 ± 1 (-8)	1.1 ± 0.6 (-9)	7 ± 4 (-9)	8.9 ± 0.3
⁶⁵ Zn	4.0 (-3)	1.4 ± 0.7 (-9)	3 ± 2 (-11)	4 ± 2 (-12)	11.7 ± 0.2
⁹⁰ Sr	— ^c	— ^c	— ^c	— ^c	— ^c
¹²⁵ Sb	<7.8 (-3)	<1.8 (-10)	<1.2 (-10)	<2.7 (-11)	>11.0
¹³⁴ Cs	7.2 (-1)	1.4 ± 0.7 (-8)	1.0 ± 0.5 (-8)	6 ± 1 (-7)	6.3 ± 0.1
¹³⁷ Cs	6.3 (-1)	2 ± 1 (-8)	9 ± 4 (-9)	5 ± 1 (-7)	6.4 ± 0.1
²⁴¹ Pu	— ^e	6.9 (-12)	7.3 (-13)	2.5 (-15)	14.6
Acid or Metal	(μg/cm ² ·s)				
Picolinic acid	8.7 (-1)	2 ± 1 (-2)	7 ± 4 (-9)	5 ± 2 (-7)	6.5 ± 0.2
Chromium	<6.7 (-3) ^d	<1.5 (-6)	<5.3 (-11)	<1.8 (-11)	>11.3
Iron	<2.6 (-3) ^d	<9.4 (-6)	<2.8 (-11)	<4.6 (-12)	>12.3
Cobalt	<2.5 (-2) ^d	<7.3 (-6)	<2.0 (-10)	<2.6 (-10)	>10.2
Nickel	5.8 (-2) ^d	7 ± 5 (-6)	5 ± 3 (-10)	1.5 ± 0.7 (-9)	9.5 ± 0.5

a. Results are for only the first 90 days of leaching.

b. Fraction of initial inventory released per square centimeter of specimen surface area per second.

c. Concentrations of radionuclide in leachate samples were not determined.

d. Not all leachate samples were analyzed for this radionuclide or metal. CFR value was estimated by interpolating measured incremental release rates.

e. Only the leachate corresponding to leaching interval number three was analyzed for ²⁴¹Pu. Leaching results are those determined for leaching interval number three.

Table 26. Leach test results for baked James A. FitzPatrick mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with pH 4.2^a

Nuclide	CFR	Release Rate		Average Effective Diffusivity (cm ² /s)	Leachability Index
		($\mu\text{Ci}/\text{cm}^2\cdot\text{s}$)	(F/cm ² ·s) ^b		
⁵⁴ Mn	1.8 (-3)	5 ± 3 (-9)	3 ± 2 (-11)	2 ± 1 (-12)	13.0 ± 0.4
⁵⁵ Fe	— ^c	— ^c	— ^c	— ^c	— ^c
⁵⁸ Co	1.3 (-2)	1.4 ± 0.6 (-8)	8 ± 3 (-11)	2.5 ± 0.8 (-11)	10.8 ± 0.1
⁶⁰ Co	1.9 (-2)	7 ± 3 (-8)	1.1 ± 0.4 (-10)	5 ± 2 (-11)	10.5 ± 0.1
⁶³ Ni	9.7 (-2) ^d	1.4 ± 0.6 (-8)	6 ± 3 (-10)	3 ± 2 (-9)	9.2 ± 0.4
⁶⁵ Zn	1.1 (-2)	2 ± 1 (-9)	6 ± 3 (-11)	1.1 ± 0.6 (-11)	11.3 ± 0.2
⁹⁰ Sr	— ^c	— ^c	— ^c	— ^c	— ^c
¹²⁵ Sb	<9.5 (-3)	<1.4 (-10)	<8.9 (-11)	<2.3 (-11)	>11.0
¹³⁴ Cs	6.2 (-1)	8 ± 3 (-9)	6 ± 2 (-9)	3.1 ± 0.6 (-7)	6.6 ± 0.1
¹³⁷ Cs	5.9 (-1)	1.5 ± 0.6 (-8)	5 ± 2 (-9)	2.3 ± 0.4 (-7)	6.7 ± 0.1
²⁴¹ Pu	— ^e	2.7 (-12)	2.8 (-13)	3.9 (-16)	15.4
Acid or Metal		(μg/cm ² ·s)			
Picolinic acid	4.2 (-1)	4 ± 2 (-3)	1.3 ± 0.5 (-9)	1.7 ± 0.7 (-8)	8.1 ± 0.2
Chromium	<6.2 (-3) ^d	<1.4 (-6)	<5.1 (-11)	<1.6 (-11)	>11.5
Iron	<3.3 (-3) ^d	<1.0 (-5)	<3.0 (-11)	<5.7 (-12)	>12.1
Cobalt	<2.5 (-2) ^d	<7.3 (-6)	<2.0 (-10)	<2.6 (-10)	>10.2
Nickel	3.5 (-2) ^d	3 ± 2 (-6)	2 ± 1 (-10)	5 ± 4 (-10)	10.1 ± 0.5

a. Results are for only the first 90 days of leaching.

b. Fraction of initial inventory released per square centimeter of specimen surface area per second.

c. Concentrations of radionuclide in leachate samples were not determined.

d. Not all leachate samples were analyzed for this radionuclide or metal. CFR value was estimated by interpolating measured incremental release rates.

e. Only the leachate corresponding to leaching interval number three was analyzed for ²⁴¹Pu. Leaching results are those determined for leaching interval number three.

water is about a factor of 2 less than that measured for the pH 10.4 ground water. These data suggest that releases for some components such as acids may be pH- or leachant chemistry-specific. This effect is evaluated in the discussion section.

The leach-test results for the FitzPatrick mixed-bed resin waste-form specimen leached in synthetic Hanford ground water with pH 8.9 are shown in Table 23. The major decontamination-process products released were ^{60}Co and ^{63}Ni , and the release rates were very similar to those that have already been discussed for the Barnwell ground water with pH 10.4. All leachability indexes were greater than 6.0. The ^{63}Ni had the lowest leachability index (i.e., 8.9) of the decontamination radionuclides.

Table 24 shows the leachability results of the FitzPatrick mixed-bed resin waste-form specimen that was leached in seawater. Only the results for ^{60}Co and ^{63}Ni were measurable. The release rates of these radionuclides were similar to the release rates of these radionuclides on other leachants and suggest that the high ionic strength of the simulated seawater leachant had little effect on the total release and leachability indexes of these radionuclides. In contrast, the CFR of picolinic acid was less than the deionized water by about a factor of five. These data suggest that the high ion strength may have affected the release of the chelating agent.

Table 25 summarizes the CFRs, release rates, and the leachability indexes for the FitzPatrick mixed-bed resin waste-form specimen that was baked and then leached in deionized water. The CFRs are similar to those of the unbaked sample that was leached in deionized water. Differences in the CFRs of the two samples are within a factor of two for all radionuclides, picolinic acid, and the stable metals. Releases from the baked sample are slightly higher ($\leq 150\%$) for ^{54}Mn , ^{65}Zn , and picolinic acid. However, these differences are minor and indicate that baking did not substantially affect releases, although the baked specimen decomposed and the unbaked specimen did not.

The leachability data for the baked FitzPatrick mixed-bed resin sample leached in synthetic Barnwell ground water with pH 4.2 are shown in Table 26. These data are similar to the data for the unbaked sample leached in synthetic Barnwell water with pH 4.2 (Table 22) with several exceptions. These exceptions are that releases from the baked sample are slightly higher ($\leq 150\%$) for ^{54}Mn and ^{65}Zn . However, these differences are minor and indicate that baking did not substantially affect CFRs and release rates from the waste-form specimen.

The results presented in Tables 20–26 indicate that cumulative releases of ^{54}Mn , ^{65}Zn , and ^{125}Sb from the FitzPatrick waste-form specimens were generally below 1%. However, five radionuclides— ^{63}Ni , ^{55}Fe , ^{60}Co , ^{65}Zn , and ^{137}Cs —had maximum CFRs of 1% or higher with values, expressed as percent of initial inventory, of 1.1%, 1.7%, 2.2%, 1.1%, and 7.3%, respectively. These data suggest radionuclide-specific differences in the leachability of various radionuclides and, for some radionuclides, there may be a pH dependence.

Leachant Effects on the Release of Radionuclides from FitzPatrick Mixed-Bed Resin Waste-Form Specimens. Leachant effects on the release of radionuclides are discussed through comparisons of the CFRs, absolute and fractional release rates, and leachability indexes of the radionuclides for which measurements were performed. The comparison of the CFRs of the principal radionuclides released by the decontamination process are shown in Figures 46 through 48 for ^{60}Co , ^{63}Ni , and ^{55}Fe . The ^{137}Cs data are presented in Figure 49 for comparison purposes.

The CFRs of ^{60}Co for the seven mixed-bed resin waste-form specimens leached in different leachants are shown as a function of the square root of leaching time in Figure 46. The CFR of ^{60}Co data for the FitzPatrick specimens plotted in Figure 46 were similar for all leachants. After 5 days, the cumulative fraction release of ^{60}Co from the unbaked specimen leached in deionized water was about 5.9×10^{-3} . The CFR from the

Figure 46. Cumulative fraction release of ^{60}Co from seven FitzPatrick ion-exchange resin waste-form specimens.

Figure 47. Cumulative fraction release of ^{63}Ni from seven FitzPatrick ion-exchange resin waste-form specimens.

Figure 48. Cumulative fraction release of ^{55}Fe from seven FitzPatrick ion-exchange resin waste-form specimens.

baked specimen leached in deionized water was slightly higher (i.e., about $1.2\text{E}-2$ at 5 days) as compared to the unbaked specimens; however, after this period, the CFR was similar for all samples. These data indicate that baking the samples and their complete decomposition had little effect on the CFR of ^{60}Co other than a relatively small difference in the initial release.

A further observation to be obtained from Figure 46 is that the CFR for the FitzPatrick specimens did not stabilize into a diffusion-driven release through the initial 90-day release period, and changes in the CFR continued through the entire 238 days. This behavior is different than that observed for the Brunswick-1 samples and will be evaluated further in the discussion section.

CFRs of ^{63}Ni from the seven FitzPatrick mixed-bed resin waste-form specimens are shown in Figure 47. The CFRs of this radionuclide are typically an order of magnitude higher than those of ^{60}Co . Examination of Figure 47 indicates that the CFR of ^{63}Ni from the

baked sample that was leached in deionized water was a factor of 2–4 higher than the CFR of ^{63}Ni from samples leached in other leachants. These data suggest that for ^{63}Ni , baking the samples increased the release from the sample and that deionized water is the most aggressive leachant. A comparison of the leachability characteristics of ^{63}Ni with ^{60}Co indicates some differences in the behavior of the two radionuclides. The CFR of ^{63}Ni tends to stabilize in a diffusion-driven release in contrast to ^{60}Co , for which the CFRs continued to increase throughout the leach test.

Figure 48 shows the CFRs of ^{55}Fe for the FitzPatrick mixed-bed resin waste form samples. The CFRs of ^{55}Fe are similar to those of ^{63}Ni , except the CFRs are about one order of magnitude lower. For this radionuclide, the CFRs are similar for all leachants. The length of time that the CFRs of ^{55}Fe are required to reach a diffusion driven release is similar to ^{63}Ni . These data suggest that the CFRs of various radionuclides follow radionuclide-specific release patterns, and

that the absolute magnitude of the release varies by radionuclide.

The CFRs of other radionuclides were not plotted except for ^{137}Cs , which is shown in Figure 49, and those shown in Appendix F. Examinations of these data indicate radionuclide-specific differences in the effects of the leachant on the waste-form specimen that apparently controlled the quantity released and when the release occurred. An examination of the ^{137}Cs CFRs shown in Figure 49 indicates that all leachants behaved similarly. These data suggest radionuclide-specific differences in leachability and that the fission-produced radionuclides appear to behave similarly to some radionuclides produced by neutron activation (e.g., ^{55}Fe and ^{63}Ni), although the magnitude of the releases varied.

The release rates from the FitzPatrick mixed-bed resin waste-form specimens, both absolute and fractional, were evaluated for radionuclides removed by the decontamination process. Release rates are summarized for the 90-day leaching period in Tables 20 through 26. The release rates for radionuclides produced by the decontamination process (i.e., ^{60}Co , ^{63}Ni , and ^{55}Fe) are evaluated in this section along with the ^{137}Cs results that are presented for comparison purposes.

The absolute release rate data for the FitzPatrick samples indicate 1–2 orders of magnitude difference that are leachant effects on the release of specific radionuclides produced by the decontamination process. In contrast, there is little or no leachant effect on the release of ^{137}Cs where the absolute release rates range from $1.1\text{--}1.5 \times 10^{-8} \mu\text{Ci}/\text{cm}^2\cdot\text{s}$.

The fractional release rate data for ^{60}Co are plotted in Figure 50. They indicate that during the initial 2 h of leaching, the release rates of ^{60}Co from the two baked waste-form specimens were significantly higher than the release rates of ^{60}Co from the five unbaked waste-form specimens. This correlates well with the fact that during the initial leaching period, the buckling and cracking

of the surfaces of the baked specimens were much more severe than that observed for the unbaked specimens (see Table 19). Release rates of ^{60}Co from the unbaked specimens increased significantly between the first and second leachings, while release rates of ^{60}Co from the two baked specimens decreased during this time. Cracking of the unbaked specimens continued during the second leaching, while cracking of the baked specimens either diminished or ceased. As shown in Figure 50, release rates of ^{60}Co decreased significantly between 7 h and 5 days, and then continued to decline when longer leaching intervals were used.

The fractional release rates of ^{63}Ni and ^{55}Fe are shown in Figures 51 and 52. These data are similar to those shown for ^{60}Co and follow the same trends as those indicated for ^{60}Co , for which most of the release occurred within the first five days and for which the average fractional release rate on the deionized water leachant was higher than that for the other radionuclides. Also, the release rates can be considered to be the same statistically.

As with the radionuclides produced through activation, the primary fission-product radionuclides showed similar fractional release rates for all leachants. The average fractional release rate data for ^{137}Cs are shown in Figure 53. The ^{137}Cs release rate plot is quite similar in shape to the ^{60}Co plot and the other activation products. As indicated in the figure, there were no apparent leachant effects on the release rates as all are similar. These data indicate that the diffusion rate out of the loose debris is not substantially faster than the release from the partially intact waste-form specimen. Mechanisms for the retention of the radionuclides are evaluated in the discussion section.

Leachability indexes of all radionuclides for the 90-day leach period for the FitzPatrick mixed-bed resin waste-form specimens are presented in Tables 20–26. The leachability indexes of the measured radionuclides ranged, for the unbaked samples, from 8.9 to 9.4 for ^{63}Ni and from 10.9 to 12.2 for ^{55}Fe and from 10.6 to 10.8 for ^{55}Fe for the baked samples, which indicates a slight reduction in the leachability index for the

Figure 49. Cumulative fraction release of ^{137}Cs from seven FitzPatrick ion-exchange resin waste-form specimens.

Figure 50. Fractional release rate of ^{60}Co from seven FitzPatrick ion-exchange resin waste-form specimens.

Figure 51. Fractional release rate of ^{63}Ni from seven FitzPatrick ion-exchange resin waste-form specimens.

Figure 52. Fractional release rate of ^{55}Fe from seven FitzPatrick ion-exchange resin waste-form specimens.

Figure 53. Fractional release rate of ^{137}Cs from seven FitzPatrick ion-exchange resin waste-form specimens.

baked samples that fell apart immediately. Differences in leachants and the baking of the samples did not substantially affect the leachability index for these radionuclides even though the baked samples decomposed during leaching.

Leachant Effects on the Release of Chelating Agents from FitzPatrick Mixed-Bed Resin Waste-Form Specimens. Leachant effects on the release of the chelating agent, picolinic acid, are discussed through comparisons of CFRs, release rates, and leachability indexes. The CFRs of picolinic acid for the various leachate samples are shown in Figure 54. Examination of Figure 54 indicates that the CFRs of all leachants ranged over about a factor of six, with the highest release from the sample that was baked and then leached in deionized water.

After 5 days and 7 leachings, CFRs of picolinic acid from the unbaked specimens, expressed as percent of initial inventory, ranged from a low of 5.9% for seawater to a high of 28% for Barnwell ground water with pH 10.4. The two baked speci-

mens were 12% in Barnwell ground water with pH 4.2 and 48% in deionized water.

Comparison of the fractional release rates of picolinic acid with the release rates of ^{60}Co and ^{137}Cs shown in Figure 55, indicates that the release of picolinic acid was much more variable than release rates of ^{60}Co and ^{137}Cs , which suggests that the release of picolinic acid was more sensitive to surface cracking than were releases of these two radionuclides.

Fractional release rates of picolinic acid from the FitzPatrick samples are shown in Figure 55. Fractional release rates of picolinic acid from the unbaked specimens during the first 5 days of leaching ranged from a low of $1.4 \times 10^{-9} \text{ F/cm}^2\cdot\text{s}$ in seawater to a high of $3.9 \times 10^{-9} \text{ F/cm}^2\cdot\text{s}$ in leachant with pH 10.4. Similar results for the two baked specimens were $2.1 \times 10^{-9} \text{ F/cm}^2\cdot\text{s}$ in leachant with pH 4.2 and $1.1 \times 10^{-8} \text{ F/cm}^2\cdot\text{s}$ in deionized water.

Comparison of the leachability indexes in Tables 20-26 indicate that the leachability

Figure 54. Cumulative fraction release of picolinic acid from seven FitzPatrick ion-exchange resin waste-form specimens.

Figure 55. Fractional release rates of picolinic acid from seven FitzPatrick ion-exchange resin waste-form specimens.

indexes of picolinic acid for the unbaked specimens ranged from 7.2 for Barnwell ground water with pH 10.4 to 8.3 for seawater and Hanford ground water. The leachability indexes of picolinic acid for the unbaked and baked specimens leached in leachant with pH 4.2 were essentially identical. Similar results for the unbaked and baked specimens leached in deionized water were 7.5 and 6.5, respectively, reflecting the fact that releases from the baked specimen were about 60% higher than from the unbaked specimen. The higher release of picolinic acid from the baked specimen leached in deionized water is likely due to the fact that the deterioration of this specimen was much more severe than that of the unbaked specimen.

Leachant Effects on the Release of Stable Metals from FitzPatrick Mixed-Bed Resin Waste-Form Specimens. The CFRs and absolute and fractional release rates of the stable metals were not plotted because all concentration data except for nickel were below the detection limits of the instrument used to perform the measurements. An assessment of the results in Appendix H, Tables H-1 through H-7, indicates no obvious trends associated with the few data points present.

In contrast to the other stable metals, nickel was detected in most leachates that were analyzed for stable metals. In the case of the unbaked specimens leached in Barnwell ground water with pH 4.2 and 10.4 and the Hanford ground water with pH 8.9, nickel was detected in 4 of the 5 leachates that were analyzed. Nickel was detected in only 2 of 5 seawater leachate samples.

Plots of the CFRs of nickel from the seven FitzPatrick waste-form specimens are shown in Figure 56. CFRs of nickel after 90 days of leaching were essentially the same for all leachates. The uncertainties in the CFRs of nickel were estimated to be about 100% after 90 days of leaching; therefore, releases of nickel were statistically the same in all seven leachants.

As was the case with the fractional release rate of ^{137}Cs , the fractional release rates of nickel in

seawater were similar to or lower than release rates of nickel in other leachants during the first 5 days of leaching; but thereafter, the release rates were higher in seawater than in the other leachants (see Figure 56). Between 5 and 90 days, the fractional release rate of nickel in seawater was $<3.0 \times 10^{-10} \text{ F/cm}^2\cdot\text{s}$, while similar values for the remaining leachants ranged from $2.0 \times 10^{-10} \text{ F/cm}^2\cdot\text{s}$ for Hanford ground water to $5.0 \times 10^{-10} \text{ F/cm}^2\cdot\text{s}$ for deionized water.

Leachability indexes of chromium, iron, cobalt, and nickel for the FitzPatrick waste-form specimens are summarized in Table 20-26. The leachability indexes of the four metals ranged from >9.2 for nickel in seawater to >12.3 for iron in the deionized water leachate. The leachability indexes of nickel are all very similar, indicating that the difference in leachants had little effect on the release. As shown in Table 6, the concentration of cobalt in the resin waste was about a factor of two higher than the concentration of nickel. Given the fact that ICP-AES-lower-limit-of-detection concentrations for cobalt and nickel were similar, the leaching results indicate that nickel was, in fact, more mobile than cobalt. The fact that the solubilities of nickel carbonate and hydroxide compounds are much higher than the solubilities of cobalt carbonate and hydroxide compounds, may, in part, explain the higher releases of nickel.

FitzPatrick Mixed-Bed Resin Long-Term Leaching Results. At the end of the initial 90-day leaching period, leaching was continued for all samples up to about 238 days. Results for the various radionuclides are shown in Figures 45 through 53 and are tabulated in Appendix H. The results generally followed the trends observed during the 90-day leaching period.

Compressive Strengths of Waste-Form Specimens

This section presents the results of compressive strength tests that were performed on waste-form specimens from Brunswick-1 and FitzPatrick. These compression tests were performed only on waste-form samples that had not

Figure 56. Cumulative fraction release of nickel from seven FitzPatrick ion-exchange resin waste-form specimens.

been leached because all of the Brunswick-1 and FitzPatrick samples lost their structural stability by the end of the leach test. Compressive strength tests were performed to determine if the waste-form specimens met stability requirements before the leaching test. In addition to the Brunswick-1 and FitzPatrick samples, samples from Indian Point-3 and Pilgrim were also compression tested. Testing of these samples does not fully satisfy the Branch Technical Position requirement that stipulates that the compression test must be performed on both the as-cast and immersion-tested waste forms. The requirement of the "Technical Position on Waste Form" (Revision 1) is that the cement-solidified waste-form specimen must exhibit a compressive strength of 500 psi following the immersion testing.

Compressive strength tests were performed on the unleached Brunswick-1 cation and mixed-bed resin waste-form specimens after they had been cured for 486 days and on the FitzPatrick baked and unbaked samples 212 days after the samples were solidified. The measured compres-

sive strengths of the Brunswick-1 and FitzPatrick samples are shown in Table 27 and are expressed as kPa and psi. In addition, Table 27 presents water-to-cement ratios, total cure times, specimen cross-sectional areas, and maximum loads achieved during compressive strength testing. Vendor information was not available at the time the measurements were performed; therefore, the water-to-cement ratios shown in Table 27 were calculated as the ratio of the weight of free interstitial water to the weight of cement and slaked lime or sodium hydroxide used during the solidification of the full-scale waste form from which the waste-form specimen was collected.

The compressive strength of each waste-form specimen was calculated by dividing the maximum load the specimen withstood by the cross-sectional area of the specimen. As shown in Table 27, the FitzPatrick compressive strengths were factors of 4-5 greater than the Brunswick-1 samples. This lower compressive strength may have contributed to the rapid decomposition of the Brunswick-1 samples, or it

Table 27. Compressive strengths of waste-form specimens

Waste Form	Decontamination Process	Water-to-Cement Ratio ^a	Cure Time of Unleached Specimens (days)	Cross-Sectional Area		Maximum Load		Compressive Strength	
				(cm ²)	(in. ²)	(kg)	(lb)	(kPa)	(psig)
Brunswick-1									
Cation	Citrox	0.27	486	26.19	4.06	721	1590	2.70 × 10 ³	392
Mixed-bed		0.30	486	25.41	3.94	903	1990	3.48 × 10 ³	505
FitzPatrick									
Baked	LOMI	0.30	212	17.54	2.72	2291	5050	1.28 × 10 ³	1857
Unbaked		0.30	212	17.42	2.70	2331	5140	1.31 × 10 ⁴	1906
Pilgrim									
Unleached ^b	DOW NS-1	0.37	1705	17.22	2.67	1120	2470	6.37 × 10 ³	924
Leached		0.37	— ^b	17.54	2.72	2522	5560	1.41 × 10 ⁴	2044
Indian Point-3 ^c									
Unleached	LOMI	0.38	1394	17.35	2.69	1075	2370	6.09 × 10 ³	883
Leached		0.38	— ^c	18.00	2.79	295	650	1.61 × 10 ³	233

a. Ratio of weight of free interstitial water to weight of cement and slaked lime or sodium hydroxide.

b. The leached waste-form specimen was cured 1.8 years prior to the initiation of leaching and then leached in deionized water for a total of about 2.1 years. The sample had been removed from the leachate for about 90 days when the compression test was performed. The unleached specimen was cured for 3.8 years before leach testing. It should be noted that the curing and leach-testing period for these waste forms do not meet the requirement of the Technical Position on Waste Form, but do meet the compressive strength requirements.

c. The waste-form specimen was cured 1.5 years before leaching and then leached in deionized water for a total of 2.1 years. The leached sample had been removed from the leachant for about 90 days when the compression test was performed. The unleached specimen was cured for 4.7 years before leach testing occurred. It should be noted that the curing and leach-testing period for these waste forms do not meet the requirement of the Technical Position on Waste Form, but do meet the compressive strength requirements.

may have indicated an inherent problem in the formulations. It is interesting to note that the Brunswick-1 cation resin waste form does not meet the BTP (Revision 1) requirement for compressive strength after leaching of 500 psi.

In the case of FitzPatrick, both the baked and unbaked waste-form specimens easily met the BTP (Revision 1) requirements with compressive strengths of approximately 1900 psi. These data suggest that the simulated exothermic temperature used in baking had little effect on the ini-

tial compressive strength of the waste-form specimen.

In addition to the Brunswick-1 and FitzPatrick compression tests, waste-form samples from the Indian Point-3 and Pilgrim reactors were compression-tested both before and after leaching. The waste-form specimen from Indian Point-3 contained decontamination resins from the cleaning of a steam generator channel head, which had been decontaminated using the LOMI process. The "leached" sample from Indian

Point-3 Station was cured for 1.5 years and then was leached in deionized water for a total of 2.1 years prior to compression testing. The second specimen, which was compression tested without being leached, was cured at ambient temperature for a total of 3.8 years before compressive strength testing. Although the cure times and the leaching period substantially exceed the ASTM C39 standard requirements, these data indicate that the leaching of the waste-form specimen substantially reduced compressive strength.

The decontamination resins from Pilgrim had been used to decontaminate the primary coolant recirculation system using the NS-1 process developed by the Dow Chemical Company. The NS-1 process employs oxalic acid, citric acid, EDTA, and DTPA. The "leached" specimen that was compression-tested had been cured at ambient temperature 1.8 years and was then leached in deionized water for a total of 2.6 years. Compressive strength testing was performed on this specimen about 90 days after the specimen was removed from the leachant. The second specimen obtained from Pilgrim Station, which was not leached, was cured at ambient temperature for a total of 4.7 years before being compression-tested. Examination of the compression test results indicates that the unleached specimen had a compressive strength about half that of the leached specimen. This behavior is unexpected; however, the results indicate that both waste-form specimens met the compressive strength requirements of Revision 1 of the BTP.

Radionuclide, Chelating Agent, and Stable Metal Inventories for the Brunswick-1 and FitzPatrick Liners

The total inventories of radionuclides and chelating agents present in the two Brunswick-1

liners and the FitzPatrick liners are shown in Appendix L. These results indicate that the full-scale cation resin waste form solidified at Brunswick-1 contained 25 ± 1 curies of beta- and/or gamma-ray-emitting radionuclides and 8.2 ± 0.6 millicuries of transuranic isotopes (greater than 99% ^{241}Pu). In addition to the radionuclide inventories in the liner, the results in Appendix L indicate that although there were no chelating agents present in the cation resin waste form, there was a total of 31 ± 0.7 kg stable metals, of which about 82% was iron.

The total inventories for the full-scale mixed-bed resin waste form solidified at Brunswick-1 were $1.20 \pm .04$ Ci of beta/gamma emitters and 7.3 ± 0.6 millicuries of transuranic isotopes, of which ^{241}Pu was again the primary TRU isotope. In addition to the radionuclides, the results in Appendix L indicate that the chelating agent inventories were 163 kg and 80 kg of citric and oxalic acids, respectively. The total metals inventory was 10.4 kg with most (about 60%) being chromium.

The inventories in the FitzPatrick mixed-bed liner were substantially higher than the Brunswick waste forms for some radionuclides. The inventory of beta/gamma emitters in the FitzPatrick liner (28 ± 0.2 curies) was similar to the Brunswick-1 cation resin waste form; however, the total transuranic content at 226 ± 17 millicuries was about a factor of 30 higher than the content of either of the Brunswick-1 liners. The picolinic acid inventory for the FitzPatrick liner was about 87 kg, and the total stable metals inventory of about 12 kg was similar to the Brunswick-1 mixed-bed liner. These data indicate substantial differences in the deposition of radionuclides in the reactor coolant systems of the two reactors and that the chelating agents and stable metals were relatively minor constituents of the overall waste form.

DISCUSSION OF LEACH-TEST RESULTS

This section presents a discussion of the results of the leach tests performed on the Brunswick-1 and FitzPatrick waste-form specimens and comparisons with prior studies on the stability of cement-solidified waste forms. Specific results to be evaluated are the loss of waste form stability that occurred for most of the Brunswick-1 and FitzPatrick specimens, pH and conductivity effects, cumulative fractional releases, release rates, leachability indexes, and compression test results.

Loss of Waste Form Stability During Leaching

The Brunswick-1 and FitzPatrick specimens all lost structural stability early in the testing program. All Brunswick-1 samples began to decompose within a few hours of the beginning of leach testing, and only those samples that were leached in seawater retained their physical shape. One of those samples (i.e., the Brunswick cation resin specimen that was leached in seawater) split into two parts within 10 hours. In contrast, most of the FitzPatrick samples retained their shape but lost structural stability within several hours due to the formation of cracks in the waste-form specimens. The remaining FitzPatrick samples behaved somewhat differently: about one third of the sample that was leached in Hanford ground water pH 8.9 decomposed during the 90-day period, and the two samples that were baked 49°C and then leached in deionized water and Barnwell ground water pH 4.2 decomposed into rubble within the first day. These data suggest the presence of a variety of chemical reactions between the waste form constituents and the leachants that caused the waste-form specimen to either decompose or to retain its shape without retaining physical stability. Possible chemical reactions that may have resulted in the loss of waste form stability are discussed in this section, and the effects of the loss of waste form stability on the leachability of the waste-form constituents are discussed in later sections.

The Brunswick-1 waste-form specimens that were leached in leachants other than seawater decomposed within a few hours, and yet the specimens that were leached in seawater maintained their structural shape through the entire leaching program (200+ days). For the specimens that decomposed, the similarity in behavior between the Brunswick-1 cation and mixed-bed resin waste-form specimens indicate that the presence of the different resin types and chelating agents in the mixed-bed specimens had no effect on the stability of the waste-form specimen and that decomposition of specimens of this type was due to other factors.

The decomposition of the Brunswick-1 specimens was similar to the behavior of the AP/Citrox waste-form specimens collected from Cooper Station that were leach-tested during a previous study¹² and suggests a generic behavior for solidified resins. Piciulo³¹ reported that simulated cement-solidified waste-form specimens containing oxalic acid, citric acid, and EDTA loaded on anion exchange resin also did not withstand immersion testing. He reported that three of five replicate waste-form specimens containing citric acid decomposed so badly during leaching in deionized water that no recognizable forms remained. Failure mechanisms have been suggested¹⁶ that include the swelling of cation resin beads, which is caused when monovalent ions (e.g., H^+ , Na^+) attached to the beads are replaced by higher-valent cations present in the cement (e.g., Ca^{+2} and Al^{+3}).

Other mechanisms that have been proposed for the loss of waste form stability include the reaction of citric acid with calcium in the cement to form insoluble calcium citrate precipitates, which may prevent the waste form from solidifying properly.³¹ The formation of calcium citrate precipitates is known to interfere with the hydration of cement. However, this reaction would not be expected to substantially accelerate the decomposition of the waste form. The fact that little or no citric acid is present in the cation waste form (and yet the behavior of the cation and mixed-bed

waste forms is similar) suggests that the formation of calcium citrates had no effect on the Brunswick-1 waste-form behavior. Another factor that may influence waste form stability is putting too much resin in the waste form. The resin loadings in the Brunswick-1 cation and mixed-bed resins were 72 to 75 volume%, respectively, whereas the loading of the FitzPatrick waste forms was 73.8 volume%.

Failure of the Brunswick-1 waste forms through swelling of the cation resin beads, is consistent with the observed behavior of the waste-form specimens, which begins with a crack formation followed by complete decomposition of the specimen. Confirmation of the potential for failure of the Brunswick-1 waste forms through swelling of the resin beads can be obtained from the behavior of the waste-form specimens that were leached in seawater, which did not fully decompose. The primary difference between the specimens leached in seawater and the specimens that decomposed is the composition of the seawater leachant, which contained relatively high concentrations of monovalent ions (e.g., potassium and sodium) and divalent ions (magnesium), as indicated in Table 5. The presence of high concentrations of these ions in the leachant could have two possible effects. First, formation of an osmotic condition could occur in which fewer water molecules would tend to move to the resin bead (high concentration of ions) from the leachant (similar concentration) and thereby cause the resin bead to minimize the increase in size that was caused by other factors. The second factor would be the competition for active sites on the resin bead between the smaller monovalent and divalent ions in the leachant and the calcium and aluminum from the cement. The behavior of the specimens that were leached in seawater would tend to support these observations. The fact that one specimen split in half and then retained its physical shape would tend to suggest that competing mechanisms were at work.

In addition to the proposed mechanisms addressed above, an additional phenomena was observed that could be affecting the behavior of the specimens. During the early part of the leach-

ing test, it was observed that both specimens leached in seawater became coated with white mineral deposits. Although the material that coated the specimens leached in seawater was not analyzed, results reported in the literature^{18,32} indicate that the precipitate was composed of the minerals brucite [$\text{Mg}(\text{OH})_2$], calcite (CaCO_3), and perhaps aragonite, which is another CaCO_3 mineral. Formation of these nonreactive compounds on the surface of the specimen could tend to passivate the surface of the specimen, thus preventing water movement and ion exchange and reducing the effects discussed above that would tend to cause swelling of the resin beads and, consequently, the decomposition of the waste-form specimen. Confirming the effects of the mechanisms discussed above requires further work that is defined in the recommendations for further study, which is in the conclusions section of this report.

The same effects described for the Brunswick-1 specimens might be expected to affect the FitzPatrick mixed-bed waste-form specimens. As noted above, substantial cracking of all the FitzPatrick specimens occurred early in the leach test, which again suggests gross physical effects such as too much resin in the waste form or swelling of the ion-exchange resins as the cause. Why the waste-form specimens did not completely decompose similar to the Brunswick-1 samples may be due to the fact that although total waste loadings of the Brunswick and FitzPatrick liners were nearly the same, either the FitzPatrick liner contained charcoal as part of the waste loading and might not be expected to expand as much as the Brunswick-1 liners, or there were differences in the manufacture of the resin (e.g., %cross-linking). Also, the FitzPatrick waste-form specimens were obtained from the liner before the liner began to set up, whereas the Brunswick-1 waste-form samples were scraped from the surface of the partially hardened cement/waste mix. This later procedure is known to be very detrimental to the stability of cement.

In addition to the potential effect of resin swelling, the FitzPatrick resin waste-form specimens contained picolinic acid, which has been reported

to affect the stability of the waste form. Experimental results reported by Bishop^{13,33} suggest that the formation of calcium picolinate hydrate may have contributed to the instability of the FitzPatrick waste-form specimens during leaching. Bishop showed that calcium picolinate gel forms above a pH of 10.3 when either slaked lime or cement are mixed with ion-exchange bead resins loaded with sufficient concentrations of picolinic acid. Because ion-exchange resin bead columns load chromatographically, some fraction of the resin beads used to process LOMI reagent slurries will have relatively high concentrations of picolinic acid, and if calcium hydroxide is used to adjust the pH of the waste during solidification, as occurred for the FitzPatrick liner, a calcium picolinate hydrate gel will likely form over these resin beads.

Because the pH of the FitzPatrick resin waste was adjusted using calcium hydroxide, and the concentration of picolinic acid in the waste was at least 2.2 wt.%, it is therefore possible that with the concentration of picolinic acid and the presence of calcium hydroxide that hydrated calcium picolinate formed during the solidification process. The formation of calcium picolinate hydrate would have removed water otherwise available for the hydration of the cement, and the formation of coatings of the gel over resin beads with high concentrations of picolinic acid might have removed water from these beads, causing them to shrink. After immersion, the expansion of the beads due to the reintroduction of water may have contributed to the cracking observed for the FitzPatrick waste-form specimens.

For the two samples that were baked, it appears that the baking process contributed to the decomposition of the two samples, as these samples were the only FitzPatrick samples that decomposed entirely. Also, the complete loss of physical stability occurred within about a day. These data suggest that dehydration of the resin beads during solidification and curing contributed to the cracking of the waste-form specimens after they were immersed in leachants. In contrast, other findings by Piciulo³¹ suggest that heat curing of the waste-form specimen (1 day at 50°C) may

improve stability. His study indicated that compressive strengths were improved for the heat-cured waste-form specimens at the end of 28 days, but there was some evidence of additional surface cracking associated with the heat-cured waste-form specimens.

Leachate pH and Conductivity

This section compares the results of the leachate pH and conductivity for the Brunswick-1 and FitzPatrick waste forms, evaluates the causes of the observed pH measurements, and assesses trends from other waste-form studies. Examination of the pH measurements for the three waste forms that were leach tested indicates that after the first few days, the pH stabilized between pH 12 and pH 12.4 for the Brunswick-1 and FitzPatrick waste-form specimens, respectively, except for the samples that were leached in seawater. Both the Brunswick and FitzPatrick samples that were leached in seawater stabilized between pH 9.5 and pH 10, with the mixed-bed resin samples from both plants closer to pH 10. Results of measurements performed as part of this study showed that the pH of deionized water and synthetic seawater leachates increased from initial values of 5.8 and 6.2, respectively, to 10.2 and 8.2, respectively, within 6 minutes following the initial immersion of cement-solidified ion-exchange resin waste-form specimens. Consequently, these data suggest that the initial pH of the leachants, with the exception of the samples leached in seawater, would quickly be affected by the chemistry of the waste-form specimen being leached and that the initial pH of the ground water should not, at least initially, have any significant effect on the leachability of species present in the waste form.

The effect of the pH adjustment and the chemistry of the cement on the specimens that were leached in leachants other than seawater can be evaluated in terms of the waste-form leachate chemical reactions. Typically, the mixture of oxides in Portland Type 1 cement contains more calcium oxide than is needed for the formation of tobermorite, $3\text{CaO}\cdot 2\text{SiO}_2\cdot 3\text{H}_2\text{O}$, and this excess

lime is converted to calcium hydroxide via hydration and is encapsulated in the cement:

Upon exposure to leachant, the calcium hydroxide would be expected to break down into its ionic components based on the solubility of the compound and to raise the pH of the leachant. The rising pH observed during the first several days of leaching was likely the result of the dissolution of increasing amounts of calcium hydroxide from the waste-form specimens into the leachates. Because non-equilibrium conditions are expected to have existed for the shorter leaching periods, increasing the leaching times from 2 h to 5 h, to 17 h, and then to 24 h, they would have increased the quantity of calcium hydroxide released during successive leachings. The increase in pH during that time also correlates with the exposure of additional surfaces through cracking and loss of material from the surfaces of the waste-form specimens.

In contrast to the early behavior of the specimens, when significant changes in the pH can be expected from the exposure of fresh surfaces on the specimens during their decomposition, the pH of the deionized and ground water leachates decreased after several days as the leachant was replaced and the amount of readily available calcium hydroxide decreased. The pH then rose to about pH 12, when leaching times were increased from 24 h to 13 days. Consequently, it can be concluded that the equilibrium pH for these waste forms was about pH 12. These data suggest that throughout the leaching period, the chemistry of the waste form would substantially control the pH of any leachant and that variations in initial leachant pH, except under special conditions that will be discussed, should not affect leachability.

In contrast to the results of this study, which suggest that pH does not significantly affect the leachability of the waste form, results of leaching studies reported by de Groot³⁴ showed that leachant pH was the main factor controlling the leaching of trace anionic elements, metals, and major elements from coal fly ash. However, in

contrast to the work by de Groot, a study performed by Dougherty³⁵ for ¹³⁷Cs and ⁵⁷Co indicated that initial leachant chemical composition and ionic strength, and not initial pH, were the main factors that controlled releases of radionuclides from the waste-form specimens. That work is in agreement with the results of this study and will be discussed further in the sections discussing the leachability of radionuclides, chelating agents, and stable metals.

The pH of the seawater followed the same pattern of behavior as the other leachates (i.e., a drop from the initial high pH followed by an increase back to the higher pH); however, in contrast to the samples leached in deionized water and ground waters, the apparent equilibrium was established at a pH of about 9.5. These data suggest that a buffered solution was formed by the seawater leachates that maintained the pH at the lower level. Based on the salts used in the preparation of the seawater leachant, both bicarbonate and bisulfate are likely candidates for the formation of the buffer through simple interactions of the carbonate and sulfate ions present in the leachate with constituents of the waste form or the leachant. Numerous formation reactions are possible for these buffers that will not be discussed here.

In addition to the obvious buffering action of the constituents of the seawater, it was observed that after the initial addition of leachant, all of the Brunswick-1 mixed-bed resin waste-form specimens effervesced, producing gas bubbles in the leachant (probably CO₂) with the exception of the sample leached in seawater. The formation of the gas bubbles was probably caused by the formation of equilibria from the following reactions:

Suppression of the formation of carbon dioxide in the seawater leachant was probably due to competition for the free H⁺ by the other seawater constituents such as the sulfate.

In contrast to the pH for the Brunswick and FitzPatrick samples, the conductivity for the samples showed more variation for those leachates for which the conductivity could be measured [i.e., the conductivity of the seawater was greater than the range of the instrument (>20 mmho/cm)]. The conductivities for the deionized and ground water samples were initially quite high (4–6 mmho/cm), as might be expected from the exposure of fresh waste-form surfaces to the leachant during the decomposition of the samples. However, the conductivity then dropped for several leaching periods as the leach rate from freshly exposed surfaces began to slow down. Thereafter, the conductivity began to increase when the leaching period was extended to 13 days. This would be expected, as an equilibrium would be expected to be established between the waste-form specimen and the leachate for longer leach intervals as noted in the discussion of pH.

The conductivities for all waste-form samples remained relatively constant throughout the 90-day leach period. However, at about 200 days, there was a sudden drop in the conductivity of the Brunswick-1 samples. Although there is no apparent reason for this drop, it will be compared with the releases of the waste-form constituents to determine if this change in conductivity has an apparent effect on the release. As previously noted, the work by Dougherty suggests that conductivity (i.e., ion concentrations in the leachates) is one of the controlling factors for the release of species from the waste form. The effect of the changes in conductivity on the release of waste-form species will be addressed in the following sections.

Release of Radionuclides

Examinations of the release of radionuclides from the Brunswick-1 and FitzPatrick samples indicates that only small fractions of the inventory of most radionuclides in the waste-form specimens was released. ^{137}Cs , a fission product, had the highest release rates. Measurements were made for ^{241}Pu ; however, the results of these measurements were near or below the detection limit for this radionuclide. The available data

indicate that the leachability index of ^{241}Pu was well above that of other radionuclides such as ^{63}Ni . Of particular importance to this study is the observation that the specimens that decomposed did not have substantially different release rates from the specimens that remained relatively intact. The following sections compare the CFR, average releases, and leachability indexes for the intact and decomposed waste-form specimens with other studies that have been performed.

Cumulative Fractional Releases and Release Rates from Waste-Form Specimens

The CFRs and absolute and fractional release rates of most of the radionuclides varied significantly based on the radionuclide for which the measurement was performed. Consequently, the major focus of the discussion will be the decontamination radionuclides, ^{60}Co , ^{63}Ni , and ^{55}Fe , followed by a discussion of the characteristic fission product, ^{137}Cs , and a summary of observations for other radionuclides. In this discussion, the release rates and the CFRs will be evaluated together to assess the effects of changes in the release rate on the cumulative fractional release.

Figure 57 shows a comparison of the CFRs of the radionuclides ^{60}Co , ^{63}Ni , and ^{55}Fe at 90 days in deionized water for the three waste-form specimens being examined as part of this study [Brunswick-1 cation (BR-CR), Brunswick-1 mixed-bed (BR-MBR), and FitzPatrick mixed-bed decontamination resins (Fitz-MBR)] and of ^{60}Co from the Cooper plant [Cooper mixed-bed resins (C-MBR) and Cooper cation resins (C-CR)]¹² for comparison purposes. This figure indicates that the FitzPatrick samples had the highest CFR of all of the specimens shown.

To assess the effects of different leachants on the release, a comparison of the CFR plots of ^{60}Co for the Brunswick-1 and FitzPatrick specimens in the results section was performed, which indicated that the Brunswick-1 cation and mixed-bed resin waste-form specimens have similar release curves with a more aggressive

Figure 57. Comparison of cumulative fractional releases for principal radionuclides in deionized water.

leachant (deionized water), but that CFR curves of the FitzPatrick samples are essentially the same for all leachates, which suggests that for FitzPatrick, differences in the leachants used had relatively little effect. The differences between the behavior of the three types of samples may be due to the fact that most of the FitzPatrick samples retained their physical shape throughout the leaching period.

An initial comparison of the Brunswick-1 CFR curves indicates that the most aggressive leachant for both the cation and mixed-bed resin was deionized water. However, the total CFR of ^{60}Co from the cation resin waste-form specimen that was leached in deionized water is about one order of magnitude less than the release from the mixed-bed resin waste-form specimen. This trend continued for most of the other leachants with the exception of the mixed-bed resin specimens that were leached in Hanford ground water pH 8.9, for which the CFR was about a factor of 10^2 greater than the CFR of the cation resin

waste-form specimen with the same leachant. These data suggest that there are leachant-specific effects on the release from the specimen that are probably due to the composition of the leachant rather than, as discussed previously, the initial pH of the leachant.

The characteristics of the leachants that resulted in higher releases from both types of Brunswick-1 waste-form specimens are probably the initial lack of ions in solution for the deionized water, and the presence of substantial amounts of calcium carbonate (2.6 g/l), sulfuric acid (1.65 g/l), and $\text{Na}_2\text{SiO}_3 \cdot 9\text{H}_2\text{O}$ (3.0 g/l) for the Hanford ground water pH 8.9. These constituents were not present to any extent in the other simulated ground waters. For deionized water, it is suggested that the lack of initial inventory of ions in the solution would tend to promote release from the waste-form specimen to the leachant. Use of deionized water is recommended as an aggressive leachant in the ANSI/ANS 16.1 procedure. In contrast, the aggressiveness of the

Hanford ground water pH 8.9 appears to be related to reactions with the mixed-bed ion-exchange resin or chelating agent components of the waste form as no comparable release was observed for the cation resin waste-form specimen, which contained no chelating agents. It is suggested that the presence of large amounts of Ca^{+2} and H^{+} may have caused the release from the waste-form specimen through exchange reactions.

The remarkably low CFRs of ^{60}Co from the Brunswick-1 waste-form specimens that completely crumbled suggest that much of the ^{60}Co was immobilized through irreversible reactions with materials in the waste-form matrix. A possible mechanism for the immobilization of ^{60}Co in the cement matrix was recently reported by Komarneni.³⁶ Komarneni investigated the reactions of divalent metal cations such as Mn^{+2} , Zn^{+2} , Co^{+2} , and Ni^{+2} with calcium silicates such as tobermorite, xonotlite, and wollastonite. A relevant finding of the study was that almost all of the Ca^{+2} in tobermorites and xonotlite was irreversibly replaced by Co^{+2} or Ni^{+2} . This study was not performed on solidified ion-exchange resins and, as discussed, much of the information shown suggests the presence of ion-exchange reactions. The fact that the disintegrations of the Brunswick-1 waste-form specimens did not result in significant releases of transition metal radionuclides might be the result of their having undergone some irreversible reactions with the calcium in the cement.

Table 28 shows a comparison of the absolute and fractional release rates from the Brunswick-1 and FitzPatrick samples at 90 days. Examination of these data indicates that the absolute release rates from FitzPatrick were typically 1-3 orders of magnitude higher than the absolute release rates from the Brunswick-1 waste-form specimens. Comparison of the absolute release rates of each radionuclide indicates that the differences in leachants had the most effect on ^{55}Fe , ^{63}Ni , and ^{60}Co . However, the absolute release rates of ^{137}Cs were similar for all leachants for each waste form.

In contrast to the absolute release rate data, the fractional release rate data shown in Table 28 indicates smaller deviations in release rates. However, there were still substantial apparent radionuclide- and leachant-specific differences in the releases from the waste-form specimens, which ranged over 1-2 orders of magnitude. The radionuclide-specific effects, as shown for each waste form, are the following: For the Brunswick-1 cation resin waste-form specimens the fractional releases of all radionuclides except ^{137}Cs vary over 1-2 orders of magnitude, with either ^{55}Fe or ^{63}Ni having the highest fractional release rate. In contrast, the fractional release rates of ^{55}Fe , ^{63}Ni , and ^{60}Co for the Brunswick-1 mixed-bed resin waste-form specimens are similar for each leachant. The FitzPatrick samples behaved similarly to the Brunswick-1 cation resin waste-form samples, in which there were radionuclide-specific differences in the fractional release rates. A more in-depth evaluation of the chemistry of the radionuclides would be required to assess the mechanisms that caused the differences in these releases.

Leachant-specific effects on the absolute and fractional release rates typically range over 1-2 orders of magnitude, and further laboratory studies would be required to assess the mechanisms that caused these differences.

Examination of the ^{60}Co fractional release rate plots for the Brunswick-1 samples confirms that, as might be expected from the CFRs, the release rates from the Brunswick-1 mixed-bed resin waste-form specimen were also higher than those from the cation resin waste-form specimen. The release rate curves indicate that the initial fractional release rate from the mixed-bed resin waste-form specimens was about 10^2 higher than the release from the cation resin waste-form specimens. The high initial release is probably due to the quick initial decomposition of the mixed-bed waste-form specimens. However, following the initial release, the fractional release rates from the mixed-bed resin waste-form specimens continued to be higher. For example, the maximum release rate from the cation resin specimen was about the same as the release rate from

Table 28. Comparison of absolute and fractional release rates for the Brunswick-1 and FitzPatrick samples

	Brunswick-1 Cation Resin Waste Form				Brunswick-1 Mixed-Bed Resin Waste Form				FitzPatrick Mixed-Bed Resin Waste Form			
	⁵⁵ Fe	⁶³ Ni	⁶⁰ Co	¹³⁷ Cs	⁵⁵ Fe	⁶³ Ni	⁶⁰ Co	¹³⁷ Cs	⁵⁵ Fe	⁶³ Ni	⁶⁰ Co	¹³⁷ Cs
Deionized water	1(-9) ^a [3(-12)] ^b	9(-11) [4(-13)]	1.9(-10) [4(-13)]	1.8(-10) [7(-11)]	1.3(-9) [6(-11)]	8(-11) [1.4(-11)]	4(-10) [2(-11)]	1.6(-10) [3(-9)]	7(-10) [7(-11)]	1.3(-8) [6(-10)]	5(-8) [7(-11)]	1.5(-8) [5(-9)]
Barnwell ground water pH 10.4	9(-11) [2(-13)]	5(-10) [5(-12)]	2.7(-11) [5(-14)]	2.3(-10) [9(-11)]	7(-11) [4(-12)]	6(-12) [1.2(-12)]	9(-11) [5(-12)]	2(-10) [5(-9)]	6(-10) [6(-11)]	2(-8) [8(-10)]	3.6(-8) [5(-11)]	1.0(-8) [4(-9)]
Barnwell ground water pH 4.2	2(-11) [4(-14)]	1.7(-10) [1.9(-12)]	1.9(-11) [4(-14)]	2(-10) [9(-11)]	4(-11) [2(-12)]	1.2(-11) [2(-12)]	8(-11) [4(-12)]	3(-10) [6(-9)]	— ^a [— ^a]	1.3(-8) [5(-10)]	5(-8) [8(-11)]	1.4(-8) [5(-9)]
Hanford ground water pH 8.9	3(-11) [6(-14)]	1.0(-9) [1.1(-11)]	2.0(-11) [4(-14)]	3(-10) [1.1(-10)]	7(-11) [5(-12)]	3(-11) [8(-12)]	3(-10) [2(-11)]	1.1(-10) [3(-9)]	5(-10) [5(-11)]	1.5(-8) [6(-10)]	3.0(-8) [4(-11)]	1.1(-8) [4(-9)]
Seawater	— ^c	— ^c	1.1(-10) [2.2(-13)]	3(-10) [1.4(-10)]	— ^c	— ^c	2.2(-11) [1.1(-12)]	9(-11) [1.5(-9)]	— ^c [— ^c]	6(-9) [3(-10)]	5(-8) [7(-11)]	1.1(-8) [4(-9)]
Baked sample in deionized water	— ^d	— ^d	— ^d	— ^d	— ^d	— ^d	— ^d	— ^d	— ^c [— ^c]	3(-8) [1.1(-9)]	1.0(-7) [1.4(-10)]	2(-8) [9(-9)]
Baked sample in Barnwell ground water pH 4.2	— ^d	— ^d	— ^d	— ^d	— ^d	— ^d	— ^d	— ^d	— ^c [— ^c]	1.4(-8) [6(-10)]	7(-8) [1.1(-10)]	1.5(-8) [5(-9)]

a. Absolute release rate in $\mu\text{Ci}/\text{cm}^2\cdot\text{s}$ at 90 days.b. Fractional release rate in $\text{Fraction}/\text{cm}^2\cdot\text{s}$.

c. Not measured.

d. Baked sample measurements not performed with this leachant.

the mixed-bed resin specimen after 90 days. These data suggest that differences in the composition of the specimens significantly affected the release rate and CFR from the Brunswick-1 waste-form specimens.

If the initial rapid degradation of the mixed-bed resin waste-form specimen had caused the higher release from the specimen, the release would be expected to slow down to levels similar to those observed for the cation resin after the initial release; however, this did not occur. Consequently, the principal components of the mixed-bed waste-form specimen that were not present in the cation resin waste-form specimen, the anion resin and the chelating agents, citric acid and oxalic acid, probably accelerated the release rate from the specimen. The mechanism that caused the augmented release is not known, but it is possible that complexation of the citric acid and oxalic acid with ^{60}Co occurred and thereby increased the rate of diffusion out of the specimen. Similar behavior was observed by Soo,¹⁶ in which the apparent formation of a picolinate complex increased the release of ^{60}Co throughout the entire leaching period.

The CFR curves of ^{60}Co for the FitzPatrick samples never flattened out but continued to move upward. The differences in the shape of the curves may be due to the fact that most of the FitzPatrick samples retained their shape during the leaching period. However, the CFR curves of the baked FitzPatrick samples that decomposed were effectively the same as those for the samples that retained their shape, which suggests that components of the waste-form specimen were responsible for the release.

Both the ^{60}Co CFRs and the release rates of the FitzPatrick mixed-bed resin waste-form specimens were about 1 order of magnitude higher than those of the Brunswick-1 mixed-bed resin waste-form specimens throughout the leaching period. The work by Soo, as noted above, indicates that picolinic acid will effectively complex ^{60}Co and can cause substantial releases throughout the leaching period. Although the concentration of picolinic acid in the FitzPatrick

sample (1 wt.%) is lower than the total concentration of chelating agents in the Brunswick-1 mixed-bed resin sample (6.1 wt.%), these data suggest that picolinic acid is a more effective complexing agent for ^{60}Co .

Comparison of the FitzPatrick CFR plots with the Brunswick-1 waste-form results for ^{60}Co indicates that the releases of all leachants from the FitzPatrick specimens were about 1 order of magnitude higher than the CFR from the Brunswick-1 mixed-bed sample and that the release rates of ^{60}Co from the FitzPatrick samples were substantially greater than the release rates from the Brunswick-1 samples, although the FitzPatrick samples retained their physical shape. These release rate data suggest that the release of ^{60}Co is augmented by the probable formation of cobalt complexes with the chelating agents. Further work recommended to confirm some of these observations is presented in the recommendations for further study in the conclusions section.

The CFRs of ^{63}Ni for 90 days are shown in Figure 57 for deionized water and indicate that the highest CFRs are for the FitzPatrick samples and that the CFR is greater than those observed for ^{60}Co . However, comparison of the leachant effects on the releases from the waste-form specimens through comparison of the CFR curves shown in the results section indicates substantial differences in the leachant effects in contrast to those observed for ^{60}Co .

For the Brunswick-1 cation resin waste-form samples, the most aggressive leachant was the Hanford ground water pH 8.9. The CFR of ^{63}Ni caused by that leachant was about 10^1 greater than any of the CFRs of ^{60}Co and was 10^1 – 10^2 greater than the CFR of ^{63}Ni caused by any other leachant used on the Brunswick-1 cation resin samples.

Comparison of the CFRs from the various Brunswick-1 cation and mixed-bed resin waste-form leachates, with the exception of the Hanford ground water pH 8.9 for the cation resin and the mixed-bed resin waste-form sample leached in deionized water, indicates that all of the CFRs of

^{63}Ni are the same within a factor of about 2–5. With the uncertainties associated with the decomposition of the waste-form specimens and measurements performed on the specimens, these data indicate that the CFRs for all leachants for both waste forms are very similar with the noted exceptions. The reason for the large CFR from the sample leached in Hanford ground water pH 8.9 is not known, but may be due to the presence of high concentrations of Ca^+ and H^+ , as was discussed previously; also, the high release from the sample leached in deionized water is not known. The similarity of the CFRs for all other leachants suggests that the release of ^{63}Ni from the specimen is relatively independent of the leachant pH and composition and the composition of the specimen. Comparison of the release rates from the Brunswick-1 waste-form specimens indicates very similar fractional release rates through the leaching period from both waste forms.

In contrast to the Brunswick-1 samples, the CFRs of ^{63}Ni from the FitzPatrick samples follow a similar pattern to that observed for ^{60}Co , in which the CFRs for all leachants were similar. However, the CFRs from the FitzPatrick waste-form samples are about 10^1 – 10^2 greater than the CFR from any of the Brunswick-1 waste-form samples. The baked samples that decomposed during the initial leaching periods exhibited CFRs that were similar to the other samples. The data indicate that the effects of the decomposition of the waste-form specimen on the releases of ^{63}Ni are minimal. The release rates from the FitzPatrick waste-form samples follow a standard diffusion-driven release pattern, with most of the release during the early part of the leach-testing program.

In summary, the CFRs of ^{63}Ni from the three waste forms, Brunswick-1 cation, mixed-bed, and FitzPatrick mixed-bed resins, on which tests were performed, indicate that there were no leachant-specific effects except for the Hanford ground water pH 8.9 on the Brunswick-1 cation resin waste-form specimen and the deionized water on the Brunswick-1 mixed-bed resin waste-form specimens. These data suggest that

leachant-specific effects are minimal for the ground waters for which measurements were performed. Although it is unfortunate that measurements could not be made for the samples leached in simulated seawater, comparisons with the ^{60}Co data suggest that the CFR of ^{63}Ni in the seawater leachate should be similar to the CFR in the other leachants. The similarity of the CFRs and release rates from the Brunswick-1 specimens suggest that the presence of the anion resin and the chelating agents, oxalic acid and citric acid, does not affect the release of ^{63}Ni in contrast to the observed effects of the difference in the waste-form composition on the release of ^{60}Co .

For the FitzPatrick waste-form specimens, the high CFRs and release rates in all leachants suggests a mechanism, possibly complexation with picolinic acid, that accelerates the release from the waste-form specimens. The similarity of the CFRs in all leachants indicates that no leachant-specific effects have occurred. However, the differences in the total CFRs and release rates between the ^{63}Ni and ^{60}Co for the FitzPatrick samples suggests that the two radionuclides leach by different mechanisms as the rates are different by factors of 2–3.

Figure 57 shows the CFRs of ^{55}Fe from the Brunswick-1 and FitzPatrick waste-form samples. In contrast to the other radionuclides discussed, the Brunswick-1 mixed-bed resin specimen experienced the highest CFR of ^{55}Fe . Examination of the CFR plots in the experimental results section indicates behavior very similar to that observed for ^{60}Co . The CFRs of ^{55}Fe from the Brunswick-1 cation resin waste-form specimen are higher than the CFR of ^{60}Co , but the leachant with the maximum CFR (deionized water) is the same for ^{55}Fe and ^{60}Co .

The CFRs and release rates of ^{55}Fe from the Brunswick-1 mixed-bed resin waste-form specimen are similar to ^{60}Co for all leachants except for the deionized water, in which the ^{55}Fe CFR is a factor of about 6 higher than the ^{60}Co CFR. The reasons for the differences in the CFR behavior of deionized water are not known but are unusual due to the similarities for all the other leachants. These data suggest that the same mechanisms that

govern the release of ^{60}Co also govern the release of ^{55}Fe . This similarity between the behavior of ^{55}Fe and ^{60}Co extend to the FitzPatrick samples from which the total CFRs of the two radionuclides are within a factor of 3–4 and the release rate behavior is similar.

For comparison purposes, the ^{137}Cs CFR and release rate plots of all leachants were evaluated for the three waste forms. Comparison of these results indicates that differences in the leachant composition had no substantial effect on the ^{137}Cs releases from the three waste forms. From the Brunswick-1 cation resin waste-form specimens, the CFRs of ^{137}Cs in all leachates were about a factor of 10–20 less than those from the Brunswick-1 mixed-bed waste-form specimens. These data again suggest that, similar to ^{60}Co , there may be a complexing effect with the chelating agents that augments the release of ^{137}Cs from the waste-form specimen.

From the FitzPatrick waste-form specimens, the CFRs of ^{137}Cs are similar to ^{60}Co , and the total CFRs from the FitzPatrick samples are about a factor of 2 higher than the CFRs from the Brunswick-1 mixed-bed resin waste-form specimens. These data suggest similar behavior to that observed for ^{60}Co , although there were differences in the magnitude of the release.

Leachability Indexes for Radionuclides

Figure 58 shows a comparison of the leachability indexes of the decontamination radionuclides for the three waste forms tested and for the Cooper mixed-bed and cation resin samples that were tested in a previous study at this laboratory.¹² In this figure, the following nomenclature was used: Brunswick-1 cation resin (BR-CR), Brunswick-1 mixed-bed resin (BR-MBR), FitzPatrick mixed-bed resin (Fitz-MBR), Cooper mixed-bed resin (C-MBR), and Cooper cation resin (C-CR). As might be expected, based on the release data for the waste forms, a comparison of the leachability indexes of the Brunswick-1 cation and mixed-bed resin waste forms and the FitzPatrick waste forms indi-

cates that the FitzPatrick waste forms had the lowest leachability indexes.

A comparison of the ^{60}Co leachability indexes indicates that all leachability indexes were similar except for the leachability index for the FitzPatrick mixed-bed resin waste form. It is important to note that these were the only samples from this study in which the chelating agent picolinic acid was used, whereas the other waste forms containing chelating agents were the Brunswick-1 mixed-bed waste forms and the Cooper mixed-bed waste form.¹² Both of these waste forms used citric and oxalic acids as chelating agents. These data suggest that the presence of the chelant, picolinic acid, may substantially reduce the leachability indexes for ^{60}Co . The leachability indexes for ^{63}Ni appeared to be similarly affected by the deionized water leachant only.

In contrast to the previous two radionuclides shown in Figure 58, the leachability indexes of ^{55}Fe were similar for all waste forms. These data suggest that ^{55}Fe behaves differently than do the other radionuclides in the presence of anion resin and chelating agents. If the principal effect is assumed to be due to the presence of chelating agents, it appears that the release of ^{55}Fe is less affected by the presence of all chelating agents.

Release of Chelating Agents

Figure 59 compares CFRs of different chelating agents from Brunswick-1 mixed-bed resin (BR-MBR), FitzPatrick mixed-bed resins (Fitz-MBR), and Cooper mixed-bed resins (C-MBR). Examinations of the CFRs of chelating agents from the Brunswick-1 and FitzPatrick samples, as shown in Figure 59 for deionized water, indicate that only small fractions of the inventory of the chelating agents were released, with picolinic acid having the highest release. Of particular importance is the observation that the waste-form specimens that decomposed had lower fractional release rates for citric acid and oxalic acid than did the FitzPatrick waste-form samples, which did not decompose entirely. Comparison of the CFRs of the decontamination radionuclides with the CFRs of the chelating

Figure 58. Comparison of leachability indexes for radionuclides in deionized water.

Figure 59. Comparison of cumulative fractional releases for chelating agents in deionized water.

agents shown in Figure 59 suggests a correlation in which the higher release of the chelating agents corresponds to generally higher radionuclide releases.

Comparison of the CFRs of the chelating agents from the Brunswick-1 and FitzPatrick mixed-bed resin waste-form specimens indicates that the CFRs of citric acid and oxalic acid from the various leachants are very similar with CFRs from $3-9 \times 10^{-3}$. However, the FitzPatrick CFRs of picolinic acid are about a factor of 10^2 higher. These data suggest that differences in the leachants used had no substantive effect on the CFRs of chelating agents from the various waste-form specimens, but that the magnitude of the release of picolinic acid suggests that it is more leachable than either citric or oxalic acid.

A comparison of the leachability indexes of the chelating agents in deionized water are shown in Figure 60. Symbols used are the same as those in Figure 59. These data indicate that the leachability indexes of the citric acid and oxalic acid

chelating agents are much higher than those of picolinic acid. As previously discussed, the low leachability index of picolinic acid and radionuclides suggests again the formation of a picolinic acid complex that increases the release of all radionuclides to some extent.

Release of Stable Metals

Examination of the CFR data for the stable metals indicates that almost all the stable metal concentrations were below the detection limit of the instrumentation, with the exception of nickel for the FitzPatrick samples. Comparison of the CFRs of nickel with ^{63}Ni indicates that the pattern of the release is very similar and that the magnitude of the releases are within a factor of 2. These data suggest that the radionuclide and the stable metals leach similarly from the waste form. It is also suggested that the release of nickel may be related to the possible formation of a complex with the chelating agent picolinic acid that increased the release of this element.

Figure 60. Comparison of leachability indexes for chelating agents in deionized water.

Compressive Strength Test Results

The results of the compressive strength tests indicate that all waste forms meet the compressive strength requirements of Revision 0 of the Branch Technical Position; however, the Brunswick-1 cation resin waste form did not meet the Revision 1 requirements of 500 psi, and the Brunswick-1 mixed-bed compressive strength is marginal at 505 psi, for the unleached waste form. In contrast, the unleached FitzPatrick waste forms had compressive strengths of 1800-1900 psi. Ironically, the waste-form specimens with the highest releases in leaching were from FitzPatrick. These data suggest that compressive strength alone is not a good indicator of the stability of a waste form.

Compressive strength tests reported by Bishop¹³ indicate that the compressive strength of a waste form containing bead resin loaded with LOMI process reagents is strongly dependent upon the water-to-cement (w/c) ratio. For w/c ratios from 0.39 to 0.77, Bishop reported that compressive strengths were inversely proportional to the w/c ratio. However, the data reported by Bishop exhibited a substantial amount of scatter, and he was unable to explain the large variations in compressive strength that were measured for specimens having similar w/c ratios. The INEL study suggests that w/c ratios do not provide good indicators of the compressive strength in these waste forms, but that other factors such as the hydration of the cement and the components of the waste form are more significant. In general, however (i.e., for a specific waste type with constant composition), w/c ratio is probably the best single indicator, other than perhaps waste loading.

CONCLUSIONS AND RECOMMENDATIONS

This section summarizes the conclusions and recommendations developed during the leach-test program performed on decontamination ion-exchange resin waste-form specimens from the Brunswick-1 (Citrox decontamination) and FitzPatrick (LOMI decontamination) nuclear power stations. The conclusions of the testing program include recommendations for further work that is needed to better understand the behavior of cement-solidified decontamination resin waste forms.

Loss of Waste Form Stability During Leaching

In this study, all of the Brunswick-1 waste-form specimens (except those leached in seawater) and the FitzPatrick samples that were baked decomposed during the leach test. The FitzPatrick samples that were not baked developed severe cracks early in the leach-testing program and were considered to have lost any form of physical stability. Decomposition occurred rapidly and early in the leach test, indicating a gross physical effect. From these data, it has been concluded that the loss of waste form stability was probably the result of a variety of competing factors including swelling of the resin beads that caused the decomposition of some samples and allowed the remainder to retain their physical shape process. Also, the resin loading of the waste form (greater than 70 volume%) may have impacted the stability of the waste form.

The fact that the specimens that were leached in seawater maintained their general physical form has been attributed to two factors: the formation of an osmotic condition between the resin bead and the high ionic strength leachant, which reduces the swelling associated with the resin beads, and the formation of a mineral surface layer of calcium carbonate and other minerals that may passivate the surface of the seawater waste-form specimen and prevent the entry of water. These effects would tend to reduce bead swelling or contact of the leachant with the

interior of the waste-form specimen and consequently protect the specimen from decomposition.

To confirm the effects of resin dehydration during solidification, followed by hydration upon leaching, additional work would be required to characterize the effects of waste form components and leachants on the resins both before and after hydration, followed by an evaluation of the overall expansion of the waste-form specimen, which might be expected. Confirmation of the behavior of the samples leached in seawater would also require a study of the expansion of resin beads in various leachants. The effects of mineral coatings on the samples could be conducted at the same time as the evaluation of the swelling of resin beads in various leachants.

Leachate pH and Conductivity. Conclusions from the evaluation of pH and conductivity measurements of the Brunswick-1 and FitzPatrick waste-form samples are that the chemistry of the waste form quickly (within several minutes) affects the pH of the leachant, and that the leachant quickly reaches an equilibrium pH. From these data, it can be concluded generally that variations in the initial pH of the leachant do not affect the CFRs or release rates of components of the waste form, such as radionuclides and chelating agents in cement-solidified wastes. An exception to this behavior is when the leachant has a high ionic strength (e.g., seawater). In seawater, the pH is probably chemically buffered to a lower pH than the waste form. No substantive differences in radionuclide and chelating agent release were observed as a result of the use of a low pH leachant.

With respect to conductivity, it has been concluded that variations in the conductivity may effect the release of radionuclides as discussed in the following section.

Releases of Radionuclides. In the evaluation of the releases of radionuclides it was concluded that several factors may affect the release of radionuclides. Deionized water is equal to or

more aggressive than ground waters and seawater with an exception. That exception is that ground waters with substantial amounts of calcium carbonate and sulfuric acid (Hanford ground water pH 8.9) seem to increase the absolute and fractional release rates from the waste-form specimen, possibly due to the establishment of a chemical equilibrium between the radionuclide (^{60}Co specifically) and the leachate, which results in an exchange of ^{60}Co ions for Ca^{+2} ions. Examination of the absolute and fractional release rate data indicates that there are significant (1–2 orders of magnitude) leachant- and radionuclide-specific effects on releases from the waste form.

An interesting conclusion of this work is that although most of the waste-form specimens disintegrated early in the leach testing, the release of radionuclides from the specimens appeared to be unaffected. The leachability indexes of all waste forms were above the recommended minimum of 6.

A primary conclusion of this work is that chelating agents cause substantial increases (10^1 – 10^2) in the release rate of all decontamination-produced radionuclides, probably through the formation of a complex between the chelating agent and the radionuclide. It also appears that citric acid and oxalic acid are less effective (typically a factor of 10) in increasing the leachability of most radionuclides from waste-forms. Further work needs to be performed to evaluate the chemistry of these interactions and to fully confirm the mechanisms involved that increase the leachability of the various radionuclides.

Further conclusions that can be made concerning the release of radionuclides are that there are radionuclide-specific differences in leachability. Typically, the magnitude of the leachability of the radionuclide varies by radionuclide. These studies show that the pattern of leachability of ^{55}Fe is similar to that of ^{60}Co , and both appear to be significantly affected by the presence of chelating agents. The release of ^{63}Ni appears to be more influenced by the presence of chelating agents. Also, the release of ^{137}Cs appears to be relatively

unaffected by differences in leachant composition and the type of decontamination waste solidified. Further work on the leachability of various radionuclides in the presence of chelating agents needs to be performed to fully assess the effects on the release of radionuclides from cement-solidified waste forms.

For the decontamination radionuclides ^{60}Co , ^{63}Ni , and ^{55}Fe , the presence of the chelating agent picolinic acid has a substantial effect on the leachability indexes and tends to reduce the leachability index by 4–5, as compared to resin waste forms with the chelating agents citric acid and oxalic acid, or waste forms without chelating agents. Other radionuclides such as ^{137}Cs and ^{125}Sb appear to be less affected by the presence of chelating agents. Measurements were made for ^{241}Pu ; however, the results of these measurements were near or below the detection limit for this radionuclide. The available data indicated that the leachability index of ^{241}Pu was well above that of other radionuclides such as ^{63}Ni .

Release of Chelating Agents. Picolinic acid is released at much higher absolute and fractional release rates than are the chelating agents citric acid and oxalic acid and, in fact, at higher levels than any other species. It is suggested that the chelating agent picolinic acid forms complexes with some radionuclides and causes substantial increases in the releases from waste forms containing this chelating agent. As indicated previously, further work is needed to define the release mechanism and to define the extent of potential releases from the waste form.

Release of Stable Metals. The releases of stable metals to the leachates were basically below the detection limit for the instrumentation used except for nickel. It was concluded that the leachability of stable nickel was very similar to that of ^{63}Ni . The substantial release of nickel from the FitzPatrick waste-form specimens may be due to the formation of some complexes between this element and the chelating agent picolinic acid.

Compression Testing. From the evaluation of the compression tests for the Brunswick-1 and

FitzPatrick samples, it is apparent that compression testing of unleached samples does not provide information on the stability of the waste form after immersion or leaching because the Brunswick-1 and FitzPatrick waste-form specimens met the BTP compression test requirements before leaching began and then quickly decomposed.

Recommendations for Future Studies

The primary recommendations for future study for this program are as follows. Further studies should be performed to evaluate the differences in release rates between samples that deteriorated and those that maintained stability during leaching. More work should be performed on the effects of differences in the curing exotherm on the releases and the effects of long-term leaching. In addition, the effects of resin dehydration during solidification followed by hydration upon leaching should be better evaluated to determine the effects of resin bead swelling and other contributing factors such as waste-to-cement ratio and chelate content that may result in decomposition or maintenance of waste form stability, and the effects of the deterioration on

radionuclide release. Further work should also be done to evaluate the expansion of resin beads in various leachants, the effects of mineral coatings on the surfaces waste-form specimens during leaching, and waste-loading effects on stability.

The very substantial effects of chelating agents on releases from waste-form specimens should be addressed. This may be the key effect in the release of radionuclides from cement-solidified waste forms. The effects of various chelating agents on various radionuclides should be studied, with particular emphasis on picolinic acid as releases from the Citrox waste-form specimens to be less affected by the presence of the chelating agent. Further work needs to be performed to evaluate the chemistry of these interactions with actual wastes rather than simulants. Also, to fully confirm the mechanisms involved that appear to increase the leachability of the various radionuclides, further studies need to be performed.

The radionuclides with which those studies should be performed include ^{63}Ni , ^{55}Fe , ^{60}Co , and ^{65}Zn because these nuclides exhibit substantial differences in behavior when exposed to different leachants and chelating agents. Other radionuclides of interest are ^{241}Pu and ^{137}Cs .

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APPENDIX A

DECONTAMINATION PROCESSES

APPENDIX A

DECONTAMINATION PROCESSES

In most instances, chemical decontamination process formulas have been developed in a competitive environment, and therefore their exact chemical compositions are considered proprietary. The following descriptions of the decontamination processes used at the commercial LWRs, from which solidified decontamination resin waste forms were collected, were obtained from the literature and do not include information of a proprietary nature.

There are two general methods that have been developed to perform full system decontaminations of LWRs: concentrated chemical processes and dilute chemical processes. The concentrated processes use reagent concentrations of between 5 and 25 wt.%, and the dilute processes that are currently employed use reagent concentrations of 1.0 wt.% or less. Based on these concentrations, the quantity of reagents required for a concentrated process decontamination range from about 48 to 248 kg of reagent per cubic meter of primary system volume to be contaminated. A similar estimate for a dilute process decontamination is less than 10 kg per cubic meter. During recent years, the dilute chemical processes have become the most widely used.

The decontamination processes used at the LWRs from which samples were obtained were dilute chemical, multi-step processes. They employed between 0.1 and 0.6 wt.% reagent and were multi-step in the respect that they required an initial oxide removal step, a chrome removal step, and a final oxide removal step. The processes were performed at low temperature [i.e., 333 to 368 K (60 to 95°C)] and atmospheric pressure. The processes, in general, use a combination of organic acids and chelating agents to dissolve the oxide film from surfaces and to suspend the resulting organo-metal complexes in solution. Corrosion inhibitors are sometimes added to reduce the attack of organic acids on carbon steel piping. Some oxide films have significant concentrations of chromium that adversely affects the dissolution of the oxide layer. Oxidizing treatments are used on such films to condition them by rendering the chromium soluble through oxidation from +3 to +6 valence state.

The reagents are slurried or dissolved in concentrated form and are injected directly into the primary system water and circulated for 1 to 3 days. During the process, the decontamination solution is passed through cation exchange resins to remove the corrosion and activation products and to regenerate the reagents. Following completion of decontamination, mixed-bed resins are normally used to remove the residual metallic ions and the decontamination reagents.

AP/CITROX

Pacific Nuclear Services developed this proprietary process for application in the United States for both PWR and BWR systems. The AP/Citrox (alkaline permanganate)/(citric acid-oxalic acid) process is a dilute, low-temperature, low-pressure process.^{1,2} The AP/Citrox process is normally performed in the following steps: A concentrated solution of citric and oxalic acids is heated and injected into the preheated system to be decontaminated. The primary coolant is circulated and continuously passed through a cation ion-exchange resin column to remove dissolved radionuclides and metal ions and to regenerate the organic acids. The effluent of the cation resin column is returned to the system being decontaminated. This process is normally continued for 8 to 12 h, at which time the primary coolant is then passed through a mixed-bed ion-exchange column to remove the organic acids and any remaining dissolved radionuclides and metals.

Following the completion of the initial Citrox decontamination step, alkaline permanganate (AP) is used to condition the oxide layer when PWR and some BWR systems are decontaminated. AP is used to remove chromium from the oxide layer since chromium inhibits the dissolution of the oxide film. After the chromium is removed, the initial Citrox decontamination step is repeated using a more dilute concentration of Citrox reagent. This third process step normally takes 4 to 6 h. The AP reagents are removed on ion-exchange resin columns. Residual MnO_2 that is formed during the oxidation process is dissolved with oxalic acid and removed on a mixed-bed resin column. Nitric acid/potassium permanganate (NP) is sometimes applied rather than AP when stainless steel systems are decontaminated.

NP/LOMI OR AP/LOMI

The LOMI^{2,3,4} (Low-Oxidation State Transition-Metal Ion) process was developed by the Central Electricity Generating Board in Great Britain and is now being marketed in the United States by Pacific Nuclear Services and Westinghouse. The basic feature of the process is the use of V^{+2} (as vanadous formate) to reduce the Fe^{+3} in oxide films to Fe^{+2} . The process involves electron stripping rather than attack of the film by acid. It is a multi-step process that normally employs a chromium removal step following the initial LOMI process. Degassed picolinic acid (as sodium picolinate) is injected into the coolant, and the coolant is circulated while being maintained at a temperature of between 353 and 363 K (80 and 95°C) under atmospheric pressure. Vanadous formate [$V(HCOO)_2$] is then injected to reduce Fe^{+3} to Fe^{+2} . The reaction destabilizes the oxide film releasing the metal ions to the solution. The excess picolinate in the reagent complexes with the metal ions and keeps them from redepositing on the system surfaces. The LOMI reagents and dissolved radionuclides and metal ions are removed from the system through treatment with ion-exchange resin columns. Both strong acid cation and weak-base anion resin columns are usually employed to process the spent LOMI reagent solution.

The initial LOMI step is followed by the injection of NP or AP solutions, which render the chromium soluble, leaving behind an iron-rich deposit that can be dissolved using the LOMI reagents. The NP (or AP) reagents are removed on ion-exchange resin columns. Residual MnO_2 that is formed during the oxidation process is dissolved with oxalic acid and removed on a mixed-bed resin column. Following the oxalic acid rinse, the initial LOMI step is repeated using a more dilute concentration of LOMI reagents. This decontamination process is commonly referred to as the LOMI/NP/LOMI (or LOMI/AP/LOMI) process. In either case, the spent reagents and corrosion products removed during decontamination are processed through ion-exchange resins, and these resins constitute the decontamination waste product.

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APPENDIX B

PHOTOS OF BRUNSWICK UNIT 1 CATION RESIN WASTE-FORM SPECIMENS

APPENDIX B

PHOTOS OF BRUNSWICK UNIT 1 CATION RESIN WASTE-FORM SPECIMENS

This appendix shows two cation resin waste-form specimens from Brunswick Unit 1 before, during, and after leaching in various solutions.

Figure B-1. Brunswick-1 cation resin waste-form specimen before leaching in seawater, top view.

Figure B-2. Brunswick-1 cation resin waste-form specimen before leaching in seawater, side view.

Figure B-3. Brunswick-1 cation resin waste-form specimen at start of leaching in seawater.

Figure B-4. Brunswick-1 cation resin waste-form specimen after leaching in seawater for 37 minutes.

Figure B-5. Brunswick-1 cation resin waste-form specimen after leaching in seawater for 56 minutes.

Figure B-6. Brunswick-1 cation resin waste-form specimen after leaching in seawater for 1 hour, 5 minutes.

Figure B-7. Brunswick-1 cation resin waste-form specimen after leaching in seawater for 1 hour, 12 minutes.

Figure B-8. Brunswick-1 cation resin waste-form specimen after leaching in seawater for 1 hour, 26 minutes.

Figure B-9. Brunswick-1 cation resin waste-form specimen after leaching in seawater for 1 hour, 35 minutes.

Figure B-10. Brunswick-1 cation resin waste-form specimen after leaching in seawater for 90 days.

Figure B-11. Brunswick-1 cation resin waste-form specimen removed from seawater after leaching for 90 days.

Figure B-12. Brunswick-1 cation resin waste-form specimen before being leached in low pH Barnwell ground water, top view.

Figure B-13. Brunswick-1 cation resin waste-form specimen before being leached in low pH Barnwell ground water, side view.

Figure B-14. Brunswick-1 cation resin waste-form specimen after leaching in low pH Barnwell ground water for 2 hours, 8 minutes.

Figure B-15. Brunswick-1 cation resin waste-form specimen after leaching in low pH Barnwell ground water for 6 hours, 18 minutes.

Figure B-16. Brunswick-1 cation resin waste-form specimen after leaching in low pH Barnwell ground water for 9 hours, 8 minutes.

APPENDIX C

**PHOTOS OF BRUNSWICK UNIT 1 MIXED-BED RESIN
WASTE-FORM SPECIMENS**

APPENDIX C

PHOTOS OF BRUNSWICK UNIT 1 MIXED-BED RESIN WASTE-FORM SPECIMENS

This appendix shows two mixed-bed resin waste-form specimens from Brunswick Unit 1 before, during, and after leaching in various solutions.

Figure C-1. Brunswick-1 mixed-bed resin waste-form specimen before being leached in seawater, top view.

Figure C-2. Brunswick-1 mixed-bed resin waste-form specimen before being leached in seawater, side view.

Figure C-3. Brunswick-1 mixed-bed resin waste-form specimen after leaching in seawater for 29 minutes.

Figure C-4. Brunswick-1 mixed-bed resin waste-form specimen after leaching in seawater for 2 hours, 38 minutes.

Figure C-5. Brunswick-1 mixed-bed resin waste-form specimen after leaching in seawater for 5 hours, 2 minutes.

Figure C-6. Brunswick-1 mixed-bed resin waste-form specimen after leaching in seawater for 90 days.

Figure C-7. Brunswick-1 mixed-bed resin waste-form specimen removed from seawater after leaching for 90 days.

Figure C-8. Brunswick-1 mixed-bed resin waste-form specimen before being leached in low pH Barnwell ground water, diagonal view.

Figure C-9. Brunswick-1 mixed-bed resin waste-form specimen after leaching in low pH Barnwell ground water for 1 hour, 31 minutes.

Figure C-10. Brunswick-1 mixed-bed resin waste-form specimen after leaching in low pH Barnwell ground water for 4 hours, 28 minutes.

Figure C-11. Brunswick-1 mixed-bed resin waste-form specimen after leaching in low pH Barnwell ground water for 6 hours, 42 minutes.

Figure C-12. Brunswick-1 mixed-bed resin waste-form specimen after leaching in low pH Barnwell ground water for 90 days.

APPENDIX D

**PHOTOS OF FITZPATRICK MIXED-BED RESIN
WASTE-FORM SPECIMENS**

APPENDIX D

PHOTOS OF FITZPATRICK MIXED-BED RESIN WASTE-FORM SPECIMENS

This appendix shows three mixed-bed resin waste-form specimens from FitzPatrick before, during, and after leaching in various solutions.

Figure D-1. FitzPatrick mixed-bed resin waste-form specimen before being leached in seawater, top view.

Figure D-2. FitzPatrick mixed-bed resin waste-form specimen before being leached in seawater, side view.

Figure D-3. FitzPatrick mixed-bed resin waste-form specimen at start of leaching in seawater.

Figure D-4. FitzPatrick mixed-bed resin waste-form specimen after leaching in seawater for 90 days.

Figure D-5. FitzPatrick mixed-bed resin waste-form specimen before being leached in demineralized water, top view.

Figure D-6. FitzPatrick mixed-bed resin waste-form specimen before being leached in demineralized water, side view.

Figure D-7. FitzPatrick mixed-bed resin waste-form specimen at start of leaching in demineralized water.

Figure D-8. FitzPatrick mixed-bed resin waste-form specimen after leaching in demineralized water for 90 days.

Figure D-9. Baked FitzPatrick mixed-bed resin waste-form specimen before being leached in demineralized water, top view.

Figure D-10. Baked FitzPatrick mixed-bed resin waste-form specimen before being leached in demineralized water, side view.

Figure D-11. Baked FitzPatrick mixed-bed resin waste-form specimen at start of leaching in demineralized water.

Figure D-12. Baked FitzPatrick mixed-bed resin waste-form specimen after leaching in demineralized water for 90 days.

APPENDIX E

PLOTS OF CUMULATIVE FRACTIONAL RELEASES AND INCREMENTAL FRACTION RELEASE RATES OF BRUNSWICK-1 WASTE-FORM SPECIMENS

APPENDIX E

PLOTS OF CUMULATIVE FRACTIONAL RELEASES AND INCREMENTAL FRACTION RELEASE RATES OF BRUNSWICK-1 WASTE-FORM SPECIMENS

Cumulative fractional releases and incremental fraction release rates of ^{125}Sb from the mixed-bed waste-form specimens are plotted versus the square root of leaching time (expressed in days) in Figures E-1 and E-2, respectively.

Figure E-1. Cumulative fraction release of ^{125}Sb from five Brunswick-1 mixed-bed resin waste-form specimens.

Figure E-2. Incremental fraction release rate of ^{125}Sb from five Brunswick-1 mixed-bed resin waste-form specimens.

APPENDIX F

PLOTS OF CUMULATIVE FRACTIONAL RELEASES AND INCREMENTAL FRACTION RELEASE RATES OF FITZPATRICK WASTE-FORM SPECIMENS

THE UNITED STATES OF AMERICA
DO hereby certify that the within and foregoing is a true and correct copy of the original as the same appears in the records of the Department of the Interior.

WITNESSED

APPENDIX F

PLOTS OF CUMULATIVE FRACTIONAL RELEASES AND INCREMENTAL FRACTION RELEASE RATES OF FITZPATRICK WASTE-FORM SPECIMENS

Cumulative fractional releases and incremental fraction release rates of ^{54}Mn from the FitzPatrick mixed-bed waste-form specimens are plotted versus the square root of leaching time (expressed in days) in Figures F-1 and F-2, respectively. Cumulative fractional releases and incremental fraction release rates of ^{65}Zn from the specimens are plotted versus the square root of leaching time (expressed in days) in Figures F-3 and F-4, respectively.

Figure F-1. Cumulative fraction release of ^{54}Mn from seven FitzPatrick ion-exchange resin waste-form specimens.

Figure F-2. Incremental fraction release rate of ^{54}Mn from seven FitzPatrick ion-exchange resin waste-form specimens.

Figure F-3. Cumulative fraction release of ^{65}Zn from seven FitzPatrick ion-exchange resin waste-form specimens.

Figure F-4. Incremental fraction release rate of ^{65}Zn from seven FitzPatrick ion-exchange resin waste-form specimens.

APPENDIX G

RADIONUCLIDE AND STABLE METAL LEACHING DATA FOR BRUNSWICK UNIT 1 WASTE-FORM SPECIMENS

APPENDIX G

RADIONUCLIDE AND STABLE METAL LEACHING DATA FOR BRUNSWICK UNIT 1 WASTE-FORM SPECIMENS

The radionuclide and stable metal leaching data for five Brunswick Unit 1 cation resin waste-form specimens are given in Tables G-1 through G-5, while similar results for five mixed-bed resin waste-form specimens obtained from Brunswick Unit 1 are given in Tables G-6 through G-10. The data in Appendix G was derived from the data located in Appendix J.

TABLE G-1. Radionuclide and stable metal leaching data for Brunswick-1 cation resin waste-form specimen leached in deionized water.

Mn-54

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.33E-02	7.23E-05	4.37E-11	4.36E-13	7.22E-07	7.22E-07	7.11E-17	1.61E+01
2*	2.93E-01	6.67E-04	1.60E-10	1.60E-12	6.66E-06	7.38E-06	7.92E-15	1.41E+01
3*	1.02E+00	7.95E-04	3.41E-11	3.41E-13	7.94E-06	1.53E-05	1.26E-15	1.49E+01
4*	2.02E+00	1.16E-03	3.64E-11	3.63E-13	1.16E-05	2.69E-05	3.50E-15	1.45E+01
5*	3.02E+00	3.15E-03	1.12E-10	1.12E-12	3.14E-05	5.84E-05	5.59E-14	1.33E+01
6*	4.03E+00	2.10E-03	7.65E-11	7.63E-13	2.09E-05	7.93E-05	3.67E-14	1.34E+01
7*	5.04E+00	2.89E-03	1.10E-10	1.10E-12	2.88E-05	1.08E-04	9.83E-14	1.30E+01
8*	1.80E+01	8.01E-04	2.39E-12	2.39E-14	8.00E-06	1.16E-04	1.08E-16	1.60E+01
9*	4.58E+01	1.21E-04	1.68E-13	1.68E-15	1.20E-06	1.17E-04	1.54E-18	1.78E+01
10*	9.09E+01	< 2.26E-04	< 2.44E-13	< 2.43E-15	< 2.26E-06	< 1.20E-04	< 7.07E-18	> 1.72E+01
11*	1.70E+02	< 8.71E-05	< 6.21E-14	< 6.20E-16	< 8.69E-07	< 1.20E-04	< 8.81E-19	> 1.81E+01
12*	2.01E+02	< 1.03E-04	< 2.24E-13	< 2.24E-15	< 1.02E-06	< 1.21E-04	< 1.67E-17	> 1.68E+01
13*	2.32E+02	< 8.95E-05	< 1.94E-13	< 1.93E-15	< 8.94E-07	< 1.22E-04	< 1.45E-17	> 1.68E+01
14*	2.84E+02	1.22E-04	1.59E-13	1.58E-15	1.22E-06	< 1.24E-04	1.16E-17	1.69E+01
15*	3.12E+02	< 6.93E-05	< 1.66E-13	< 1.66E-15	< 6.92E-07	< 1.24E-04	< 1.48E-17	> 1.68E+01
16*	3.88E+02	3.51E-04	3.11E-13	3.10E-15	3.50E-06	< 1.28E-04	6.03E-17	1.62E+01
Mean: < 3.61E-11 < 3.60E-13								< 1.27E-14 > 1.57E+01
Standard Deviation: 1.29E-11 1.29E-13								6.96E-15 4.13E-01

Fe-55

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.33E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.93E-01	3.08E-02	7.40E-09	1.40E-11	5.82E-05	NA	6.05E-13	1.22E+01
3*	1.02E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.02E+00	3.68E-04	1.15E-11	2.18E-14	6.96E-07	NA	1.26E-17	1.69E+01
5*	3.02E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.03E+00	9.72E-04	3.54E-11	6.70E-14	1.84E-06	NA	2.83E-16	1.55E+01
7*	5.04E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.80E+01	1.93E-04	5.76E-13	1.09E-15	3.64E-07	NA	2.24E-19	1.86E+01
9*	4.58E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.09E+01	3.04E-03	3.28E-12	6.19E-15	5.74E-06	NA	4.57E-17	1.63E+01
11*	1.70E+02	NA	NA	NA	NA	NA	NA	NA
12*	2.01E+02	NA	NA	NA	NA	NA	NA	NA
13*	2.32E+02	NA	NA	NA	NA	NA	NA	NA
14*	2.84E+02	NA	NA	NA	NA	NA	NA	NA
15*	3.12E+02	NA	NA	NA	NA	NA	NA	NA
16*	3.88E+02	NA	NA	NA	NA	NA	NA	NA
(90 Days) Mean: 1.49E-09 2.82E-12								1.21E-13 1.59E+01
Standard Deviation: 1.48E-09 2.79E-12								1.21E-13 1.06E+00

TABLE G-1. Radionuclide and stable metal leaching data for Brunswick-1 cation resin waste-form specimen leached in deionized water. (continued)

Co-58

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.33E-02	< 1.23E-03	< 7.40E-10	< 7.17E-11	< 1.19E-04	< 1.19E-04	< 1.93E-12	> 1.17E+01
2*	2.93E-01	< 3.17E-03	< 7.61E-10	< 7.38E-11	< 3.07E-04	< 4.26E-04	< 1.68E-11	> 1.08E+01
3*	1.02E+00	< 2.58E-03	< 1.11E-10	< 1.07E-11	< 2.50E-04	< 6.76E-04	< 1.24E-12	> 1.19E+01
4*	2.02E+00	< 2.14E-03	< 6.70E-11	< 6.50E-12	< 2.08E-04	< 8.83E-04	< 1.12E-12	> 1.20E+01
5*	3.02E+00	< 4.30E-03	< 1.53E-10	< 1.48E-11	< 4.17E-04	< 1.30E-03	< 9.84E-12	> 1.10E+01
6*	4.03E+00	< 5.18E-03	< 1.89E-10	< 1.83E-11	< 5.02E-04	< 1.80E-03	< 2.11E-11	> 1.07E+01
7*	5.04E+00	< 3.44E-03	< 1.31E-10	< 1.27E-11	< 3.33E-04	< 2.14E-03	< 1.31E-11	> 1.09E+01
8*	1.80E+01	< 3.17E-03	< 9.48E-12	< 9.19E-13	< 3.08E-04	< 2.44E-03	< 1.60E-13	> 1.28E+01
9*	4.58E+01	< 2.55E-03	< 3.55E-12	< 3.44E-13	< 2.47E-04	< 2.69E-03	< 6.45E-14	> 1.32E+01
10*	9.09E+01	< 3.15E-03	< 3.39E-12	< 3.29E-13	< 3.05E-04	< 2.99E-03	< 1.29E-13	> 1.29E+01
11*	1.70E+02	< 5.65E-03	< 4.03E-12	< 3.91E-13	< 5.47E-04	< 3.54E-03	< 3.49E-13	> 1.25E+01
12*	2.01E+02	< 4.02E-03	< 8.80E-12	< 8.52E-13	< 3.90E-04	< 3.93E-03	< 2.42E-12	> 1.16E+01
13*	2.32E+02	< 7.25E-03	< 1.57E-11	< 1.52E-12	< 7.02E-04	< 4.63E-03	< 8.96E-12	> 1.10E+01
14*	2.84E+02	< 5.85E-03	< 7.59E-12	< 7.36E-13	< 5.67E-04	< 5.20E-03	< 2.50E-12	> 1.16E+01
15*	3.12E+02	< 6.58E-03	< 1.58E-11	< 1.53E-12	< 6.38E-04	< 5.84E-03	< 1.25E-11	> 1.09E+01
16*	3.88E+02	ND	ND	ND	ND	ND	ND	ND
=====								
Mean: < 1.48E-10 < 1.43E-11							< 6.15E-12 > 1.17E+01	
Standard Deviation: 6.52E-11 6.32E-12							1.81E-12 2.14E-01	

Co-60

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.33E-02	2.08E-04	1.25E-10	2.50E-13	4.15E-07	4.15E-07	2.35E-17	1.66E+01
2*	2.93E-01	1.89E-03	4.55E-10	9.08E-13	3.78E-06	4.19E-06	2.55E-15	1.46E+01
3*	1.02E+00	3.20E-03	1.37E-10	2.74E-13	6.39E-06	1.06E-05	8.12E-16	1.51E+01
4*	2.02E+00	4.25E-03	1.33E-10	2.66E-13	8.49E-06	1.91E-05	1.87E-15	1.47E+01
5*	3.02E+00	1.11E-02	3.95E-10	7.88E-13	2.22E-05	4.13E-05	2.78E-14	1.36E+01
6*	4.03E+00	6.70E-03	2.44E-10	4.88E-13	1.34E-05	5.46E-05	1.50E-14	1.38E+01
7*	5.04E+00	1.03E-02	3.94E-10	7.87E-13	2.06E-05	7.52E-05	5.03E-14	1.33E+01
8*	1.80E+01	3.25E-03	9.69E-12	1.93E-14	6.48E-06	8.17E-05	7.08E-17	1.61E+01
9*	4.58E+01	1.01E-03	1.41E-12	2.81E-15	2.01E-06	8.37E-05	4.29E-18	1.74E+01
10*	9.09E+01	7.68E-04	8.27E-13	1.65E-15	1.53E-06	8.53E-05	3.25E-18	1.75E+01
11*	1.70E+02	9.18E-04	6.55E-13	1.31E-15	1.83E-06	8.71E-05	3.91E-18	1.74E+01
12*	2.01E+02	1.08E-03	2.37E-12	4.73E-15	2.16E-06	8.93E-05	7.44E-17	1.61E+01
13*	2.32E+02	1.35E-03	2.93E-12	5.84E-15	2.70E-06	9.20E-05	1.33E-16	1.59E+01
14*	2.84E+02	5.63E-04	7.31E-13	1.46E-15	1.12E-06	9.31E-05	9.84E-18	1.70E+01
15*	3.12E+02	4.14E-04	9.93E-13	1.98E-15	8.26E-07	9.39E-05	2.10E-17	1.67E+01
16*	3.88E+02	4.73E-03	4.19E-12	8.37E-15	9.45E-06	1.03E-04	4.38E-16	1.54E+01
=====								
Mean: 1.19E-10 2.38E-13							6.19E-15 1.57E+01	
Standard Deviation: 4.09E-11 8.18E-14							3.49E-15 3.50E-01	

TABLE G-1. Radionuclide and stable metal leaching data for Brunswick-1 cation resin waste-form specimen leached in deionized water. (continued)

Ni-63

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.33E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.93E-01	1.27E-03	3.05E-10	3.13E-12	1.30E-05	NA	3.03E-14	1.35E+01
3*	1.02E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.02E+00	2.44E-04	7.64E-12	7.83E-14	2.50E-06	NA	1.63E-16	1.58E+01
5*	3.02E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.03E+00	5.50E-03	2.01E-10	2.06E-12	5.64E-05	NA	2.67E-13	1.26E+01
7*	5.04E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.80E+01	1.68E-04	5.02E-13	5.15E-15	1.72E-06	NA	5.01E-18	1.73E+01
9*	4.58E+01	7.22E-03	1.01E-11	1.03E-13	7.40E-05	NA	5.79E-15	1.42E+01
10*	9.09E+01	9.78E-03	1.05E-11	1.08E-13	1.00E-04	NA	1.39E-14	1.39E+01
11*	1.70E+02	NA	NA	NA	NA	NA	NA	NA
12*	2.01E+02	NA	NA	NA	NA	NA	NA	NA
13*	2.32E+02	NA	NA	NA	NA	NA	NA	NA
14*	2.84E+02	NA	NA	NA	NA	NA	NA	NA
15*	3.12E+02	NA	NA	NA	NA	NA	NA	NA
16*	3.88E+02	NA	NA	NA	NA	NA	NA	NA
=====								
(90 Days)		Mean:	8.91E-11	9.13E-13			5.28E-14	1.45E+01
Standard Deviation:			5.35E-11	5.49E-13			4.30E-14	6.99E-01

Zn-65

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.33E-02	< 1.40E-04	< 8.45E-11	< 1.27E-11	< 2.11E-05	< 2.11E-05	< 6.08E-14	> 1.32E+01
2*	2.93E-01	< 2.62E-04	< 6.29E-11	< 9.47E-12	< 3.94E-05	< 6.05E-05	< 2.78E-13	> 1.26E+01
3*	1.02E+00	< 2.30E-04	< 9.88E-12	< 1.49E-12	< 3.47E-05	< 9.53E-05	< 2.40E-14	> 1.36E+01
4*	2.02E+00	< 3.36E-04	< 1.05E-11	< 1.58E-12	< 5.06E-05	< 1.46E-04	< 6.66E-14	> 1.32E+01
5*	3.02E+00	< 3.90E-04	< 1.38E-11	< 2.09E-12	< 5.88E-05	< 2.05E-04	< 1.95E-13	> 1.27E+01
6*	4.03E+00	< 4.41E-04	< 1.61E-11	< 2.42E-12	< 6.65E-05	< 2.71E-04	< 3.70E-13	> 1.24E+01
7*	5.04E+00	< 3.41E-04	< 1.30E-11	< 1.96E-12	< 5.14E-05	< 3.22E-04	< 3.13E-13	> 1.25E+01
8*	1.80E+01	< 1.93E-04	< 5.77E-13	< 8.70E-14	< 2.91E-05	< 3.52E-04	< 1.43E-15	> 1.48E+01
9*	4.58E+01	< 2.58E-04	< 3.60E-13	< 5.43E-14	< 3.89E-05	< 3.91E-04	< 1.60E-15	> 1.48E+01
10*	9.09E+01	< 3.76E-04	< 4.05E-13	< 6.11E-14	< 5.67E-05	< 4.47E-04	< 4.45E-15	> 1.44E+01
11*	1.70E+02	< 1.69E-04	< 1.20E-13	< 1.81E-14	< 2.54E-05	< 4.73E-04	< 7.54E-16	> 1.51E+01
12*	2.01E+02	< 3.55E-04	< 7.77E-13	< 1.17E-13	< 5.35E-05	< 5.26E-04	< 4.56E-14	> 1.33E+01
13*	2.32E+02	< 1.84E-04	< 3.97E-13	< 5.99E-14	< 2.77E-05	< 5.54E-04	< 1.39E-14	> 1.39E+01
14*	2.84E+02	< 2.18E-04	< 2.83E-13	< 4.26E-14	< 3.29E-05	< 5.87E-04	< 8.40E-15	> 1.41E+01
15*	3.12E+02	< 1.98E-04	< 4.76E-13	< 7.17E-14	< 2.99E-05	< 6.17E-04	< 2.75E-14	> 1.36E+01
16*	3.88E+02	< 1.54E-03	< 1.37E-12	< 2.06E-13	< 2.33E-04	< 8.49E-04	< 2.66E-13	> 1.26E+01
=====								
Mean:		< 1.35E-11	< 2.03E-12				< 1.05E-13	> 1.35E+01
Standard Deviation:			6.13E-12	9.24E-13			3.27E-14	2.24E-01

TABLE G-1. Radionuclide and stable metal leaching data for Brunswick-1 cation resin waste-form specimen leached in deionized water. (continued)

Sr-90

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.33E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.93E-01	5.48E-03	1.32E-09	4.84E-09	2.01E-02	NA	7.23E-08	7.14E+00
3*	1.02E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.02E+00	4.73E-05	1.48E-12	5.44E-12	1.74E-04	NA	7.87E-13	1.21E+01
5*	3.02E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.03E+00	5.44E-05	1.98E-12	7.29E-12	2.00E-04	NA	3.35E-12	1.15E+01
7*	5.04E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.80E+01	2.56E-05	7.63E-14	2.80E-13	9.39E-05	NA	1.49E-14	1.38E+01
9*	4.58E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.09E+01	8.71E-05	9.38E-14	3.45E-13	3.20E-04	NA	1.42E-13	1.28E+01
11*	1.70E+02	NA	NA	NA	NA	NA	NA	NA
12*	2.01E+02	NA	NA	NA	NA	NA	NA	NA
13*	2.32E+02	NA	NA	NA	NA	NA	NA	NA
14*	2.84E+02	NA	NA	NA	NA	NA	NA	NA
15*	3.12E+02	NA	NA	NA	NA	NA	NA	NA
16*	3.88E+02	NA	NA	NA	NA	NA	NA	NA
=====								
(90 days)		Mean:	2.64E-10	9.70E-10			1.45E-08	1.15E+01
		Standard Deviation:	2.63E-10	9.66E-10			1.45E-08	1.15E+00

Sb-125

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.33E-02	< 1.05E-04	< 6.33E-11	< 2.62E-10	< 4.33E-04	< 4.33E-04	< 2.56E-11	> 1.06E+01
2*	2.93E-01	< 1.38E-04	< 3.30E-11	< 1.37E-10	< 5.69E-04	< 1.00E-03	< 5.77E-11	> 1.02E+01
3*	1.02E+00	< 1.04E-04	< 4.46E-12	< 1.84E-11	< 4.29E-04	< 1.43E-03	< 3.67E-12	> 1.14E+01
4*	2.02E+00	< 1.71E-04	< 5.34E-12	< 2.21E-11	< 7.06E-04	< 2.14E-03	< 1.30E-11	> 1.09E+01
5*	3.02E+00	< 1.76E-04	< 6.25E-12	< 2.58E-11	< 7.28E-04	< 2.86E-03	< 2.99E-11	> 1.05E+01
6*	4.03E+00	< 1.17E-04	< 4.27E-12	< 1.77E-11	< 4.84E-04	< 3.35E-03	< 1.97E-11	> 1.07E+01
7*	5.04E+00	< 1.13E-04	< 4.31E-12	< 1.78E-11	< 4.67E-04	< 3.82E-03	< 2.58E-11	> 1.06E+01
8*	1.80E+01	< 1.18E-04	< 3.51E-13	< 1.45E-12	< 4.86E-04	< 4.30E-03	< 3.98E-13	> 1.24E+01
9*	4.58E+01	< 1.80E-04	< 2.52E-13	< 1.04E-12	< 7.46E-04	< 5.05E-03	< 5.89E-13	> 1.22E+01
10*	9.09E+01	< 1.72E-04	< 1.86E-13	< 7.67E-13	< 7.12E-04	< 5.76E-03	< 7.02E-13	> 1.22E+01
11*	1.70E+02	< 9.01E-05	< 6.43E-14	< 2.66E-13	< 3.72E-04	< 6.13E-03	< 1.62E-13	> 1.28E+01
12*	2.01E+02	< 1.22E-04	< 2.68E-13	< 1.11E-12	< 5.06E-04	< 6.64E-03	< 4.08E-12	> 1.14E+01
13*	2.32E+02	< 1.47E-04	< 3.19E-13	< 1.32E-12	< 6.09E-04	< 7.25E-03	< 6.74E-12	> 1.12E+01
14*	2.84E+02	< 1.67E-04	< 2.17E-13	< 8.96E-13	< 6.91E-04	< 7.94E-03	< 3.71E-12	> 1.14E+01
15*	3.12E+02	< 1.06E-04	< 2.54E-13	< 1.05E-12	< 4.38E-04	< 8.38E-03	< 5.91E-12	> 1.12E+01
16*	3.88E+02	< 1.27E-04	< 1.13E-13	< 4.67E-13	< 5.27E-04	< 8.90E-03	< 1.36E-12	> 1.19E+01
=====								
		Mean:	< 7.69E-12	< 3.18E-11			< 1.24E-11	> 1.14E+01
		Standard Deviation:	4.22E-12	1.74E-11			3.96E-12	1.90E-01

TABLE G-1. Radionuclide and stable metal leaching data for Brunswick-1 cation resin waste-form specimen leached in deionized water. (continued)

Cs-134

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.33E-02	< 5.62E-05	< 3.39E-11	< 5.61E-10	< 9.29E-04	< 9.29E-04	< 1.18E-10	> 9.93E+00
2*	2.93E-01	1.58E-04	3.80E-11	6.28E-10	2.61E-03	< 3.54E-03	1.22E-09	8.91E+00
3*	1.02E+00	1.64E-04	7.03E-12	1.16E-10	2.71E-03	< 6.25E-03	1.46E-10	9.84E+00
4*	2.02E+00	2.13E-04	6.65E-12	1.10E-10	3.52E-03	< 9.77E-03	3.22E-10	9.49E+00
5*	3.02E+00	1.99E-04	7.05E-12	1.17E-10	3.28E-03	< 1.31E-02	6.10E-10	9.21E+00
6*	4.03E+00	8.49E-05	3.10E-12	5.12E-11	1.40E-03	< 1.45E-02	1.65E-10	9.78E+00
7*	5.04E+00	< 8.75E-05	< 3.34E-12	< 5.53E-11	< 1.45E-03	< 1.59E-02	< 2.48E-10	> 9.61E+00
8*	1.80E+01	1.09E-04	3.27E-13	5.41E-12	1.81E-03	< 1.77E-02	5.53E-12	1.13E+01
9*	4.58E+01	9.35E-05	1.30E-13	2.15E-12	1.55E-03	< 1.93E-02	2.53E-12	1.15E+01
10*	9.09E+01	< 8.53E-05	< 9.19E-14	< 1.52E-12	< 1.41E-03	< 2.07E-02	< 2.75E-12	> 1.16E+01
11*	1.70E+02	< 3.88E-05	< 2.77E-14	< 4.58E-13	< 6.42E-04	< 2.13E-02	< 4.80E-13	> 1.23E+01
12*	2.01E+02	< 4.55E-05	< 9.97E-14	< 1.65E-12	< 7.53E-04	< 2.21E-02	< 9.03E-12	> 1.10E+01
13*	2.32E+02	< 3.56E-05	< 7.70E-14	< 1.27E-12	< 5.89E-04	< 2.27E-02	< 6.30E-12	> 1.12E+01
14*	2.84E+02	< 4.25E-05	< 5.51E-14	< 9.11E-13	< 7.02E-04	< 2.34E-02	< 3.84E-12	> 1.14E+01
15*	3.12E+02	< 3.40E-05	< 8.17E-14	< 1.35E-12	< 5.63E-04	< 2.39E-02	< 9.77E-12	> 1.10E+01
16*	3.88E+02	2.34E-04	2.07E-13	3.42E-12	3.86E-03	< 2.78E-02	7.33E-11	1.01E+01
Mean: < 6.26E-12 < 1.04E-10								< 1.84E-10 > 1.05E+01
Standard Deviation: 2.98E-12 4.93E-11								8.04E-11 2.54E-01

Cs-137

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.33E-02	8.95E-04	5.40E-10	2.04E-10	3.38E-04	3.38E-04	1.56E-11	1.08E+01
2*	2.93E-01	1.96E-03	4.71E-10	1.78E-10	7.40E-04	1.08E-03	9.78E-11	1.00E+01
3*	1.02E+00	5.22E-03	2.24E-10	8.46E-11	1.97E-03	3.05E-03	7.75E-11	1.01E+01
4*	2.02E+00	5.49E-03	1.72E-10	6.49E-11	2.08E-03	5.13E-03	1.12E-10	9.95E+00
5*	3.02E+00	4.89E-03	1.73E-10	6.56E-11	1.85E-03	6.97E-03	1.93E-10	9.71E+00
6*	4.03E+00	2.85E-03	1.04E-10	3.93E-11	1.08E-03	8.05E-03	9.74E-11	1.00E+01
7*	5.04E+00	1.80E-03	6.88E-11	2.60E-11	6.81E-04	8.73E-03	5.49E-11	1.03E+01
8*	1.80E+01	3.76E-03	1.12E-11	4.24E-12	1.42E-03	1.02E-02	3.40E-12	1.15E+01
9*	4.58E+01	2.92E-03	4.07E-12	1.54E-12	1.11E-03	1.13E-02	1.29E-12	1.19E+01
10*	9.09E+01	1.49E-03	1.60E-12	6.05E-13	5.62E-04	1.18E-02	4.37E-13	1.24E+01
11*	1.70E+02	6.29E-04	4.49E-13	1.70E-13	2.38E-04	1.21E-02	6.59E-14	1.32E+01
12*	2.01E+02	2.97E-04	6.49E-13	2.45E-13	1.12E-04	1.22E-02	2.00E-13	1.27E+01
13*	2.32E+02	1.68E-04	3.63E-13	1.37E-13	6.35E-05	1.22E-02	7.33E-14	1.31E+01
14*	2.84E+02	1.10E-04	1.43E-13	5.41E-14	4.17E-05	1.23E-02	1.35E-14	1.39E+01
15*	3.12E+02	1.05E-04	2.52E-13	9.53E-14	3.97E-05	1.23E-02	4.85E-14	1.33E+01
16*	3.88E+02	3.39E-04	3.00E-13	1.13E-13	1.28E-04	1.24E-02	8.06E-14	1.31E+01
Mean: 1.11E-10 4.19E-11								4.09E-11 1.16E+01
Standard Deviation: 4.29E-11 1.62E-11								1.46E-11 3.71E-01

TABLE G-1. Radionuclide and stable metal leaching data for Brunswick-1 cation resin waste-form specimen leached in deionized water. (continued)

Pu-241

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.33E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.93E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.02E+00	< 3.09E-05	< 1.33E-12	< 3.43E-12	< 7.99E-05	NA	< 1.27E-13	> 1.29E+01
4*	2.02E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.02E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.03E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.04E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.80E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.58E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.09E+01	NA	NA	NA	NA	NA	NA	NA
Mean:			NA	NA			NA	NA
Standard Deviation:			NA	NA			NA	NA

Fe

SAMPLE NUMBER	TOTAL TIME (days)	QUANTITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.33E-02	4.73E+01	2.85E-05	2.36E-11	3.90E-05	3.90E-05	2.08E-13	1.27E+01
2*	2.93E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.02E+00	7.07E+01	3.03E-06	2.50E-12	5.84E-05	NA	6.79E-14	1.32E+01
4*	2.02E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.02E+00	4.07E+02	1.45E-05	1.19E-11	3.36E-04	NA	6.39E-12	1.12E+01
6*	4.03E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.04E+00	1.56E+02	5.94E-06	4.91E-12	1.28E-04	NA	1.95E-12	1.17E+01
8*	1.80E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.58E+01	6.16E+01	8.58E-08	7.09E-14	5.08E-05	NA	2.73E-15	1.46E+01
10*	9.09E+01	NA	NA	NA	NA	NA	NA	NA
(90 days)		Mean:	1.04E-05	8.59E-12			1.72E-12	1.27E+01
		Standard Deviation:	5.13E-06	4.23E-12			1.22E-12	5.89E-01

Ni

SAMPLE NUMBER	TOTAL TIME (days)	QUANTITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.33E-02	< 9.00E+01	< 5.43E-05	< 3.96E-10	< 6.56E-04	< 6.56E-04	< 5.87E-11	> 1.02E+01
2*	2.93E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.02E+00	< 8.84E+01	< 3.79E-06	< 2.76E-11	< 6.44E-04	NA	< 8.27E-12	> 1.11E+01
4*	2.02E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.02E+00	< 8.48E+01	< 3.01E-06	< 2.19E-11	< 6.18E-04	NA	< 2.16E-11	> 1.07E+01
6*	4.03E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.04E+00	< 9.16E+01	< 3.50E-06	< 2.55E-11	< 6.67E-04	NA	< 5.27E-11	> 1.03E+01
8*	1.80E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.58E+01	< 8.80E+01	< 1.23E-07	< 8.94E-13	< 6.41E-04	NA	< 4.35E-13	> 1.24E+01
10*	9.09E+01	NA	NA	NA	NA	NA	NA	NA
(90 days)		Mean:	< 1.30E-05	< 9.44E-11			< 2.84E-11	> 1.09E+01
		Standard Deviation:	1.04E-05	7.56E-11			1.17E-11	3.91E-01

TABLE 6-1. Radionuclide and stable metal leaching data for Brunswick-1 cation resin waste-form specimen leached in deionized water. (continued)

Co

SAMPLE NUMBER	TOTAL TIME (days)	QUANTITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.33E-02	< 1.13E+02	< 6.79E-05	< 1.73E-09	< 2.86E-03	< 2.86E-03	< 1.12E-09	> 8.95E+00
2*	2.93E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.02E+00	< 1.11E+02	< 4.74E-06	< 1.21E-10	< 2.81E-03	NA	< 1.57E-10	> 9.80E+00
4*	2.02E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.02E+00	< 1.06E+02	< 3.76E-06	< 9.57E-11	< 2.70E-03	NA	< 4.11E-10	> 9.39E+00
6*	4.03E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.04E+00	< 1.14E+02	< 4.37E-06	< 1.11E-10	< 2.91E-03	NA	< 1.00E-09	> 9.00E+00
8*	1.80E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.58E+01	< 1.10E+02	< 1.53E-07	< 3.90E-12	< 2.80E-03	NA	< 8.28E-12	> 1.11E+01
10*	9.09E+01	NA	NA	NA	NA	NA	NA	NA
=====								
(90 days)		Mean:	< 1.62E-05	< 4.12E-10				
Standard Deviation:			1.30E-05	3.30E-10				
							< 5.40E-10	> 9.64E+00
							2.23E-10	3.91E-01

Cr

SAMPLE NUMBER	TOTAL TIME (days)	QUANTITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.33E-02	< 2.25E+01	< 1.36E-05	< 1.60E-10	< 2.65E-04	< 2.65E-04	< 9.60E-12	> 1.10E+01
2*	2.93E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.02E+00	1.33E+01	5.69E-07	6.70E-12	1.56E-04	NA	4.86E-13	1.23E+01
4*	2.02E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.02E+00	3.82E+01	1.35E-06	1.60E-11	4.50E-04	NA	1.14E-11	1.09E+01
6*	4.03E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.04E+00	< 2.29E+01	< 8.74E-07	< 1.03E-11	< 2.70E-04	NA	< 8.61E-12	> 1.11E+01
8*	1.80E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.58E+01	< 2.20E+01	< 3.07E-08	< 3.61E-13	< 2.59E-04	NA	< 7.11E-14	> 1.31E+01
10*	9.09E+01	NA	NA	NA	NA	NA	NA	NA
=====								
(90 days)		Mean:	< 3.28E-06	< 3.87E-11				
Standard Deviation:			2.58E-06	3.05E-11				
							< 6.04E-12	> 1.17E+01
							2.40E-12	4.43E-01

TABLE G-2. Radionuclide and stable metal leaching data for Brunswick-1 cation resin water-form specimen leached in synthetic Barnwell ground water with pH 10.4.

Mn-54

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	< 1.01E-04	< 6.00E-11	< 5.95E-13	< 1.00E-06	< 1.00E-06	< 1.36E-16	> 1.59E+01
2*	2.96E-01	< 1.46E-04	< 3.45E-11	< 3.42E-13	< 1.45E-06	< 2.45E-06	< 3.72E-16	> 1.54E+01
3*	1.01E+00	2.45E-04	1.19E-11	1.18E-13	2.43E-06	< 4.89E-06	1.53E-16	1.58E+01
4*	2.01E+00	< 8.94E-05	< 3.35E-12	< 3.32E-14	< 8.87E-07	< 5.77E-06	< 2.95E-17	> 1.65E+01
5*	3.01E+00	2.82E-04	1.31E-11	1.30E-13	2.80E-06	< 8.57E-06	7.63E-16	1.51E+01
6*	4.00E+00	< 1.08E-04	< 5.79E-12	< 5.74E-14	< 1.08E-06	< 9.65E-06	< 2.10E-16	> 1.57E+01
7*	5.01E+00	< 6.15E-05	< 3.45E-12	< 3.43E-14	< 6.10E-07	< 1.03E-05	< 9.65E-17	> 1.60E+01
8*	1.81E+01	< 7.41E-05	< 3.20E-13	< 3.17E-15	< 7.35E-07	< 1.10E-05	< 1.94E-18	> 1.77E+01
9*	4.59E+01	< 1.15E-04	< 2.46E-13	< 2.44E-15	< 1.14E-06	< 1.21E-05	< 3.32E-18	> 1.75E+01
10*	9.10E+01	< 8.08E-05	< 1.07E-13	< 1.06E-15	< 8.01E-07	< 1.29E-05	< 1.37E-18	> 1.79E+01
11*	1.70E+02	< 1.90E-04	< 1.52E-13	< 1.51E-15	< 1.89E-06	< 1.48E-05	< 5.32E-18	> 1.73E+01
12*	2.01E+02	< 1.53E-04	< 3.34E-13	< 3.31E-15	< 1.51E-06	< 1.63E-05	< 3.70E-17	> 1.64E+01
		Mean:	< 1.11E-11	< 1.10E-13			< 1.51E-16	> 1.64E+01
		Standard Deviation:	5.28E-12	5.24E-14			6.43E-17	2.71E-01

Fe-55

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.96E-01	1.54E-03	3.63E-10	6.81E-13	2.89E-06	NA	1.47E-15	1.48E+01
3*	1.01E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.01E+00	2.83E-04	1.06E-11	1.99E-14	5.32E-07	NA	1.06E-17	1.70E+01
5*	3.01E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.00E+00	3.29E-04	1.75E-11	3.29E-14	6.17E-07	NA	6.92E-17	1.62E+01
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.81E+01	7.27E-03	3.14E-11	5.89E-14	1.36E-05	NA	6.69E-16	1.52E+01
9*	4.59E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.10E+01	3.86E-03	5.10E-12	9.56E-15	7.24E-06	NA	1.11E-16	1.60E+01
11*	1.70E+02	NA	NA	NA	NA	NA	NA	NA
12*	2.01E+02	NA	NA	NA	NA	NA	NA	NA
(90 days)		Mean:	8.55E-11	1.60E-13			4.67E-16	1.58E+01
		Standard Deviation:	6.95E-11	1.30E-13			2.78E-16	3.78E-01

Co-58

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	< 1.62E-03	< 9.64E-10	< 9.28E-11	< 1.56E-04	< 1.56E-04	< 3.31E-12	> 1.15E+01
2*	2.96E-01	< 3.08E-03	< 7.25E-10	< 6.98E-11	< 2.96E-04	< 4.53E-04	< 1.55E-11	> 1.08E+01
3*	1.01E+00	< 1.62E-03	< 7.89E-11	< 7.59E-12	< 1.56E-04	< 6.09E-04	< 6.31E-13	> 1.22E+01
4*	2.01E+00	< 1.44E-03	< 5.39E-11	< 5.19E-12	< 1.39E-04	< 7.47E-04	< 7.21E-13	> 1.21E+01
5*	3.01E+00	< 2.06E-03	< 9.52E-11	< 9.17E-12	< 1.98E-04	< 9.45E-04	< 3.81E-12	> 1.14E+01
6*	4.00E+00	< 5.02E-03	< 2.68E-10	< 2.58E-11	< 4.83E-04	< 1.43E-03	< 4.25E-11	> 1.04E+01
7*	5.01E+00	< 1.77E-03	< 9.97E-11	< 9.60E-12	< 1.71E-04	< 1.60E-03	< 7.58E-12	> 1.11E+01
8*	1.81E+01	< 1.94E-03	< 8.36E-12	< 8.04E-13	< 1.86E-04	< 1.79E-03	< 1.25E-13	> 1.29E+01
9*	4.59E+01	< 1.80E-03	< 3.86E-12	< 3.71E-13	< 1.73E-04	< 1.96E-03	< 7.66E-14	> 1.31E+01
10*	9.10E+01	< 1.95E-03	< 2.58E-12	< 2.49E-13	< 1.88E-04	< 2.15E-03	< 7.53E-14	> 1.31E+01
11*	1.70E+02	< 7.54E-03	< 6.04E-12	< 5.82E-13	< 7.26E-04	< 2.87E-03	< 7.89E-13	> 1.21E+01
12*	2.01E+02	< 4.79E-03	< 1.05E-11	< 1.01E-12	< 4.61E-04	< 3.33E-03	< 3.44E-12	> 1.15E+01
		Mean:	< 1.93E-10	< 1.86E-11			< 6.55E-12	> 1.19E+01
		Standard Deviation:	9.16E-11	8.82E-12			3.51E-12	2.59E-01

TABLE G-2. Radionuclide and stable metal leaching data for Brunswick-1 cation resin water-form specimen leached in synthetic Barnwell ground water with pH 10.4. (continued)

Co-60

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	1.52E-04	9.02E-11	1.79E-13	3.01E-07	3.01E-07	1.23E-17	1.69E+01
2*	2.96E-01	1.53E-04	3.59E-11	7.12E-14	3.02E-07	6.04E-07	1.61E-17	1.68E+01
3*	1.01E+00	1.03E-03	5.00E-11	9.92E-14	2.04E-06	2.65E-06	1.08E-16	1.60E+01
4*	2.01E+00	4.45E-04	1.67E-11	3.31E-14	8.83E-07	3.53E-06	2.93E-17	1.65E+01
5*	3.01E+00	1.19E-03	5.51E-11	1.09E-13	2.36E-06	5.89E-06	5.41E-16	1.53E+01
6*	4.00E+00	1.59E-04	8.49E-12	1.68E-14	3.15E-07	6.20E-06	1.81E-17	1.67E+01
7*	5.01E+00	1.90E-04	1.07E-11	2.12E-14	3.77E-07	6.58E-06	3.68E-17	1.64E+01
8*	1.81E+01	6.20E-04	2.68E-12	5.31E-15	1.23E-06	7.81E-06	5.43E-18	1.73E+01
9*	4.59E+01	4.13E-04	8.86E-13	1.76E-15	8.18E-07	8.63E-06	1.72E-18	1.78E+01
10*	9.10E+01	1.42E-03	1.87E-12	3.71E-15	2.81E-06	1.14E-05	1.68E-17	1.68E+01
11*	1.70E+02	6.50E-04	5.21E-13	1.03E-15	1.29E-06	1.27E-05	2.49E-18	1.76E+01
12*	2.01E+02	3.47E-04	7.58E-13	1.50E-15	6.87E-07	1.34E-05	7.64E-18	1.71E+01
Mean:			2.28E-11	4.52E-14			6.63E-17	1.68E+01
Standard Deviation:			8.34E-12	1.65E-14			4.40E-17	1.97E+01

Ni-63

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.96E-01	9.10E-03	2.14E-09	2.18E-11	9.26E-05	NA	1.51E-12	1.18E+01
3*	1.01E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.01E+00	2.27E-03	8.49E-11	8.65E-13	2.31E-05	NA	2.00E-14	1.37E+01
5*	3.01E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.00E+00	1.55E-03	8.25E-11	8.40E-13	1.57E-05	NA	4.51E-14	1.33E+01
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.81E+01	6.20E-03	2.68E-11	2.72E-13	6.31E-05	NA	1.43E-14	1.38E+01
9*	4.59E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.10E+01	1.73E-03	2.29E-12	2.33E-14	1.77E-05	NA	6.63E-16	1.52E+01
11*	1.70E+02	NA	NA	NA	NA	NA	NA	NA
12*	2.01E+02	NA	NA	NA	NA	NA	NA	NA
(90 days) Mean:			4.68E-10	4.76E-12			3.19E-13	1.36E+01
Standard Deviation:			4.19E-10	4.27E-12			2.99E-13	5.38E-01

Zn-65

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	< 1.14E-04	< 6.77E-11	< 1.01E-11	< 1.71E-05	< 1.71E-05	< 3.95E-14	> 1.34E+01
2*	2.96E-01	< 2.07E-04	< 4.88E-11	< 7.30E-12	< 3.10E-05	< 4.81E-05	< 1.70E-13	> 1.28E+01
3*	1.01E+00	< 1.63E-04	< 7.90E-12	< 1.18E-12	< 2.44E-05	< 7.24E-05	< 1.53E-14	> 1.38E+01
4*	2.01E+00	< 1.25E-04	< 4.67E-12	< 6.99E-13	< 1.87E-05	< 9.11E-05	< 1.31E-14	> 1.39E+01
5*	3.01E+00	< 2.37E-04	< 1.10E-11	< 1.65E-12	< 3.56E-05	< 1.27E-04	< 1.23E-13	> 1.29E+01
6*	4.00E+00	< 3.40E-04	< 1.82E-11	< 2.72E-12	< 5.09E-05	< 1.78E-04	< 4.72E-13	> 1.23E+01
7*	5.01E+00	< 1.22E-04	< 6.88E-12	< 1.03E-12	< 1.83E-05	< 1.96E-04	< 8.72E-14	> 1.31E+01
8*	1.81E+01	< 1.48E-04	< 6.38E-13	< 9.55E-14	< 2.21E-05	< 2.18E-04	< 1.76E-15	> 1.48E+01
9*	4.59E+01	< 1.66E-04	< 3.56E-13	< 5.33E-14	< 2.48E-05	< 2.43E-04	< 1.58E-15	> 1.48E+01
10*	9.10E+01	< 3.27E-04	< 4.33E-13	< 6.48E-14	< 4.90E-05	< 2.92E-04	< 5.11E-15	> 1.43E+01
11*	1.70E+02	< 2.36E-04	< 1.89E-13	< 2.83E-14	< 3.53E-05	< 3.27E-04	< 1.86E-15	> 1.47E+01
12*	2.01E+02	< 1.83E-04	< 4.00E-13	< 5.99E-14	< 2.74E-05	< 3.55E-04	< 1.21E-14	> 1.39E+01
Mean:			< 1.39E-11	< 2.08E-12			< 7.85E-14	> 1.37E+01
Standard Deviation:			6.29E-12	9.42E-13			3.92E-14	2.42E-01

TABLE G-2. Radionuclide and stable metal leaching data for Brunswick-1 cation resin water-form specimen leached in synthetic Barnwell ground water with pH 10.4. (continued)

Sr-90

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	2.58E-05	1.53E-11	5.59E-11	9.42E-05	9.42E-05	1.20E-12	1.19E+01
2*	2.96E-01	3.20E-05	7.54E-12	2.75E-11	1.17E-04	2.11E-04	2.41E-12	1.16E+01
3*	1.01E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.01E+00	2.03E-05	7.62E-13	2.78E-12	7.43E-05	NA	2.07E-13	1.27E+01
5*	3.01E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.00E+00	2.03E-05	1.08E-12	3.96E-12	7.41E-05	NA	1.00E-12	1.20E+01
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.81E+01	3.37E-03	1.45E-11	5.30E-11	1.23E-02	NA	5.42E-10	9.27E+00
9*	4.59E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.10E+01	3.29E-03	4.35E-12	1.59E-11	1.20E-02	NA	3.07E-10	9.51E+00
11*	1.70E+02	NA	NA	NA	NA	NA	NA	NA
12*	2.01E+02	NA	NA	NA	NA	NA	NA	NA
=====								
(90 days)		Mean:	7.26E-12	2.65E-11			1.42E-10	1.12E+01
Standard Deviation:			2.63E-12	9.58E-12			9.43E-11	5.81E-01

Sb-125

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	< 1.63E-04	< 9.69E-11	< 3.98E-10	< 6.70E-04	< 6.70E-04	< 6.08E-11	> 1.02E+01
2*	2.96E-01	< 1.39E-04	< 3.28E-11	< 1.35E-10	< 5.72E-04	< 1.24E-03	< 5.77E-11	> 1.02E+01
3*	1.01E+00	< 1.85E-04	< 8.99E-12	< 3.69E-11	< 7.60E-04	< 2.00E-03	< 1.49E-11	> 1.08E+01
4*	2.01E+00	< 1.01E-04	< 3.79E-12	< 1.56E-11	< 4.16E-04	< 2.42E-03	< 6.50E-12	> 1.12E+01
5*	3.01E+00	< 1.72E-04	< 7.98E-12	< 3.27E-11	< 7.07E-04	< 3.13E-03	< 4.87E-11	> 1.03E+01
6*	4.00E+00	1.69E-04	9.03E-12	3.71E-11	6.94E-04	< 3.82E-03	8.77E-11	1.01E+01
7*	5.01E+00	< 9.76E-05	< 5.48E-12	< 2.25E-11	< 4.01E-04	< 4.22E-03	< 4.17E-11	> 1.04E+01
8*	1.81E+01	< 9.76E-05	< 4.21E-13	< 1.73E-12	< 4.01E-04	< 4.62E-03	< 5.77E-13	> 1.22E+01
9*	4.59E+01	< 1.82E-04	< 3.90E-13	< 1.60E-12	< 7.46E-04	< 5.37E-03	< 1.43E-12	> 1.18E+01
10*	9.10E+01	< 8.60E-05	< 1.14E-13	< 4.67E-13	< 3.53E-04	< 5.72E-03	< 2.65E-13	> 1.26E+01
11*	1.70E+02	< 1.27E-04	< 1.02E-13	< 4.18E-13	< 5.21E-04	< 6.24E-03	< 4.07E-13	> 1.24E+01
12*	2.01E+02	< 1.36E-04	< 2.98E-13	< 1.22E-12	< 5.60E-04	< 6.80E-03	< 5.07E-12	> 1.13E+01
=====								
Mean:		< 1.39E-11	< 5.69E-11				< 2.72E-11	> 1.11E+01
Standard Deviation:			7.99E-12	3.28E-11			8.83E-12	2.69E-01

Cs-134

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	9.91E-05	5.89E-11	9.67E-10	1.63E-03	1.63E-03	3.59E-10	9.44E+00
2*	2.96E-01	2.46E-04	5.80E-11	9.52E-10	4.04E-03	5.67E-03	2.89E-09	8.54E+00
3*	1.01E+00	2.03E-04	9.84E-12	1.62E-10	3.33E-03	9.00E-03	2.86E-10	9.54E+00
4*	2.01E+00	2.07E-04	7.74E-12	1.27E-10	3.39E-03	1.24E-02	4.32E-10	9.36E+00
5*	3.01E+00	9.01E-05	4.17E-12	6.85E-11	1.48E-03	1.39E-02	2.13E-10	9.67E+00
6*	4.00E+00	1.33E-04	7.10E-12	1.17E-10	2.18E-03	1.61E-02	8.69E-10	9.06E+00
7*	5.01E+00	5.87E-05	3.30E-12	5.41E-11	9.63E-04	1.70E-02	2.41E-10	9.62E+00
8*	1.81E+01	1.17E-04	5.05E-13	8.29E-12	1.92E-03	1.89E-02	1.33E-11	1.09E+01
9*	4.59E+01	< 6.08E-05	< 1.31E-13	< 2.15E-12	< 9.99E-04	< 1.99E-02	< 2.56E-12	> 1.16E+01
10*	9.10E+01	< 6.70E-05	< 8.86E-14	< 1.45E-12	< 1.10E-03	< 2.10E-02	< 2.57E-12	> 1.16E+01
11*	1.70E+02	< 8.85E-05	< 7.09E-14	< 1.16E-12	< 1.45E-03	< 2.25E-02	< 3.16E-12	> 1.15E+01
12*	2.01E+02	< 5.29E-05	< 1.16E-13	< 1.90E-12	< 8.69E-04	< 2.34E-02	< 1.22E-11	> 1.09E+01
=====								
Mean:		< 1.25E-11	< 2.05E-10				< 4.43E-10	> 1.01E+01
Standard Deviation:			6.27E-12	1.03E-10			2.34E-10	3.12E-01

TABLE G-2. Radionuclide and stable metal leaching data for Brunswick-1 cation resin water-form specimen leached in synthetic Barnwell ground water with pH 10.4. (continued)

Cs-137

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	1.52E-03	9.02E-10	3.39E-10	5.70E-04	5.70E-04	4.41E-11	1.04E+01
2*	2.96E-01	2.28E-03	5.37E-10	2.02E-10	8.56E-04	1.43E-03	1.29E-10	9.89E+00
3*	1.01E+00	5.74E-03	2.79E-10	1.05E-10	2.15E-03	3.58E-03	1.20E-10	9.92E+00
4*	2.01E+00	6.80E-03	2.55E-10	9.56E-11	2.55E-03	6.13E-03	2.45E-10	9.61E+00
5*	3.01E+00	2.58E-03	1.19E-10	4.48E-11	9.69E-04	7.10E-03	9.13E-11	1.00E+01
6*	4.00E+00	2.17E-03	1.16E-10	4.36E-11	8.16E-04	7.92E-03	1.21E-10	9.92E+00
7*	5.01E+00	1.55E-03	8.71E-11	3.27E-11	5.81E-04	8.50E-03	8.78E-11	1.01E+01
8*	1.81E+01	3.61E-03	1.56E-11	5.85E-12	1.36E-03	9.85E-03	6.60E-12	1.12E+01
9*	4.59E+01	2.58E-03	5.54E-12	2.08E-12	9.69E-04	1.08E-02	2.41E-12	1.16E+01
10*	9.10E+01	1.33E-03	1.75E-12	6.59E-13	4.98E-04	1.13E-02	5.28E-13	1.23E+01
11*	1.70E+02	6.85E-04	5.49E-13	2.06E-13	2.57E-04	1.16E-02	9.89E-14	1.30E+01
12*	2.01E+02	3.02E-04	6.60E-13	2.48E-13	1.13E-04	1.17E-02	2.08E-13	1.27E+01
Mean:			1.93E-10	7.25E-11			7.07E-11	1.09E+01
Standard Deviation:			7.94E-11	2.98E-11			2.20E-11	3.53E-01

Pu-241

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.96E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.01E+00	< 3.15E-05	< 1.53E-12	< 3.92E-12	< 8.07E-05	NA	< 1.68E-13	> 1.28E+01
4*	2.01E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.01E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.00E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.59E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
Mean:			NA	NA			NA	NA
Standard Deviation:			NA	NA			NA	NA

Fe

SAMPLE NUMBER	TOTAL TIME (days)	QUANTITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.61E-02	< 7.39E+02	< 4.58E-04	< 4.15E-10	< 6.70E-04	< 6.70E-04	< 5.63E-11	> 1.02E+01
2*	2.96E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.01E+00	< 8.10E+02	< 4.26E-05	< 3.86E-11	< 7.34E-04	NA	< 1.36E-11	> 1.09E+01
4*	2.01E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.01E+00	< 7.28E+02	< 3.08E-05	< 2.80E-11	< 6.60E-04	NA	< 2.95E-11	> 1.05E+01
6*	4.01E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.01E+00	< 7.99E+02	< 3.36E-05	< 3.05E-11	< 7.24E-04	NA	< 6.35E-11	> 1.02E+01
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.59E+01	< 7.88E+02	< 1.20E-06	< 1.09E-12	< 7.14E-04	NA	< 5.48E-13	> 1.23E+01
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
(90 days) Mean:			< 1.13E-04	< 1.03E-10			< 3.27E-11	> 1.08E+01
Standard Deviation:			8.64E-05	7.83E-11			1.21E-11	3.79E-01

TABLE G-2. Radionuclide and stable metal leaching data for Brunswick-1 cation resin water-form specimen leached in synthetic Barnwell ground water with pH 10.4. (continued)

Ni

SAMPLE NUMBER	TOTAL TIME (days)	QUANTITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	< 3.88E+02	< 2.30E-04	< 1.67E-09	< 2.81E-03	< 2.81E-03	< 1.07E-09	> 8.97E+00
2*	2.96E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.01E+00	< 4.50E+02	< 2.18E-05	< 1.58E-10	< 3.26E-03	NA	< 2.74E-10	> 9.56E+00
4*	2.01E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.01E+00	< 3.74E+02	< 1.73E-05	< 1.25E-10	< 2.71E-03	NA	< 7.13E-10	> 9.15E+00
6*	4.00E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.01E+00	< 3.76E+02	< 2.11E-05	< 1.53E-10	< 2.72E-03	NA	< 1.92E-09	> 8.72E+00
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.59E+01	< 4.48E+02	< 9.62E-07	< 6.96E-12	< 3.24E-03	NA	< 2.70E-11	> 1.06E+01
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
=====								
(90 days)		Mean:	< 5.83E-05	< 4.22E-10			< 8.01E-10	> 9.39E+00
Standard Deviation:			4.32E-05	3.13E-10			3.33E-10	3.25E-01

Co

SAMPLE NUMBER	TOTAL TIME (days)	QUANTITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	< 4.85E+02	< 2.88E-04	< 7.27E-09	< 1.23E-02	< 1.23E-02	< 2.04E-08	> 7.69E+00
2*	2.96E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.01E+00	< 5.63E+02	< 2.73E-05	< 6.90E-10	< 1.42E-02	NA	< 5.21E-09	> 8.28E+00
4*	2.01E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.01E+00	< 4.68E+02	< 2.16E-05	< 5.47E-10	< 1.18E-02	NA	< 1.36E-08	> 7.87E+00
6*	4.00E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.01E+00	< 4.70E+02	< 2.64E-05	< 6.67E-10	< 1.19E-02	NA	< 3.66E-08	> 7.44E+00
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.59E+01	< 5.60E+02	< 1.20E-06	< 3.04E-11	< 1.41E-02	NA	< 5.14E-10	> 9.29E+00
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
=====								
(90 days)		Mean:	< 7.29E-05	< 1.84E-09			< 1.53E-08	> 8.11E+00
Standard Deviation:			5.40E-05	1.36E-09			6.34E-09	3.25E-01

Cr

SAMPLE NUMBER	TOTAL TIME (days)	QUANTITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	< 9.70E+01	< 5.76E-05	< 6.74E-10	< 1.14E-03	< 1.14E-03	< 1.75E-10	> 9.76E+00
2*	2.96E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.01E+00	< 1.13E+02	< 5.46E-06	< 6.39E-11	< 1.32E-03	NA	< 4.47E-11	> 1.03E+01
4*	2.01E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.01E+00	< 1.87E+01	< 8.66E-07	< 1.01E-11	< 2.19E-04	NA	< 4.66E-12	> 1.13E+01
6*	4.00E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.01E+00	< 9.40E+01	< 5.28E-06	< 6.18E-11	< 1.10E-03	NA	< 3.14E-10	> 9.50E+00
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.59E+01	< 1.12E+02	< 2.41E-07	< 2.82E-12	< 1.31E-03	NA	< 4.41E-12	> 1.14E+01
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
=====								
(90 days)		Mean:	< 1.39E-05	< 1.63E-10			< 1.09E-10	> 1.05E+01
Standard Deviation:			1.10E-05	1.28E-10			6.02E-11	3.86E-01

TABLE G-3. Radionuclide and stable metal leaching data for Brunswick-1 cation resin waste-form specimen leached in synthetic Barnwell groundwater with pH 4.2.

Mn-54

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.61E-02	< 7.11E-05	< 4.40E-11	< 4.83E-13	< 7.80E-07	< 7.80E-07	< 7.63E-17	> 1.61E+01
2*	2.96E-01	5.20E-05	7.92E-12	8.68E-14	5.71E-07	< 1.35E-06	2.01E-17	1.67E+01
3*	1.01E+00	< 4.90E-05	< 2.58E-12	< 2.83E-14	< 5.37E-07	< 1.89E-06	< 7.25E-18	> 1.71E+01
4*	2.01E+00	< 5.90E-05	< 2.34E-12	< 2.56E-14	< 6.47E-07	< 2.53E-06	< 1.46E-17	> 1.68E+01
5*	3.01E+00	< 6.04E-05	< 2.56E-12	< 2.81E-14	< 6.62E-07	< 3.20E-06	< 2.97E-17	> 1.65E+01
6*	4.01E+00	< 1.04E-04	< 4.39E-12	< 4.81E-14	< 1.14E-06	< 4.33E-06	< 1.23E-16	> 1.59E+01
7*	5.01E+00	< 7.09E-05	< 2.99E-12	< 3.27E-14	< 7.77E-07	< 5.11E-06	< 7.32E-17	> 1.61E+01
8*	1.81E+01	< 6.82E-05	< 2.21E-13	< 2.42E-15	< 7.47E-07	< 5.86E-06	< 9.40E-19	> 1.80E+01
9*	4.59E+01	< 1.48E-04	< 2.26E-13	< 2.48E-15	< 1.62E-06	< 7.48E-06	< 2.84E-18	> 1.75E+01
10*	9.10E+01	< 6.81E-05	< 6.39E-14	< 7.01E-16	< 7.46E-07	< 8.23E-06	< 4.97E-19	> 1.83E+01
11*	1.70E+02	< 7.55E-05	< 4.97E-14	< 5.45E-16	< 8.28E-07	< 9.05E-06	< 5.75E-19	> 1.82E+01
12*	2.01E+02	< 1.12E-04	< 2.47E-13	< 2.71E-15	< 1.23E-06	< 1.03E-05	< 2.06E-17	> 1.67E+01
Mean:								< 3.08E-17 > 1.70E+01
Standard Deviation:								1.13E-17 2.42E-01

Fe-55

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.61E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.96E-01	1.51E-04	2.29E-11	4.76E-14	3.12E-07	NA	6.02E-18	1.72E+01
3*	1.01E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.01E+00	1.45E-03	5.73E-11	1.19E-13	3.00E-06	NA	3.14E-16	1.55E+01
5*	3.01E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.01E+00	3.81E-04	1.61E-11	3.34E-14	7.90E-07	NA	5.93E-17	1.62E+01
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.81E+01	2.71E-03	8.78E-12	1.82E-14	5.62E-06	NA	5.32E-17	1.63E+01
9*	4.59E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.10E+01	7.75E-04	7.28E-13	1.51E-15	1.61E-06	NA	2.31E-18	1.76E+01
11*	1.70E+02	NA	NA	NA	NA	NA	NA	NA
12*	2.01E+02	NA	NA	NA	NA	NA	NA	NA
(90 days) Mean:								8.70E-17 1.66E+01
Standard Deviation:								5.80E-17 3.81E-01

Co-58

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.61E-02	< 2.86E-03	< 1.77E-09	< 1.89E-10	< 3.05E-04	< 3.05E-04	< 1.17E-11	> 1.09E+01
2*	2.96E-01	< 1.68E-03	< 2.56E-10	< 2.72E-11	< 1.79E-04	< 4.84E-04	< 1.98E-12	> 1.17E+01
3*	1.01E+00	< 2.49E-03	< 1.31E-10	< 1.40E-11	< 2.65E-04	< 7.49E-04	< 1.77E-12	> 1.18E+01
4*	2.01E+00	< 2.56E-03	< 1.01E-10	< 1.08E-11	< 2.72E-04	< 1.02E-03	< 2.58E-12	> 1.16E+01
5*	3.01E+00	< 1.50E-03	< 6.34E-11	< 6.75E-12	< 1.59E-04	< 1.18E-03	< 1.72E-12	> 1.18E+01
6*	4.01E+00	< 3.44E-03	< 1.46E-10	< 1.55E-11	< 3.66E-04	< 1.55E-03	< 1.27E-11	> 1.09E+01
7*	5.01E+00	< 2.73E-03	< 1.15E-10	< 1.23E-11	< 2.91E-04	< 1.84E-03	< 1.03E-11	> 1.10E+01
8*	1.81E+01	< 2.48E-03	< 8.04E-12	< 8.55E-13	< 2.64E-04	< 2.10E-03	< 1.17E-13	> 1.29E+01
9*	4.59E+01	< 3.08E-03	< 4.71E-12	< 5.01E-13	< 3.28E-04	< 2.43E-03	< 1.16E-13	> 1.29E+01
10*	9.10E+01	< 2.05E-03	< 1.92E-12	< 2.05E-13	< 2.18E-04	< 2.65E-03	< 4.24E-14	> 1.34E+01
11*	1.70E+02	< 4.17E-03	< 2.75E-12	< 2.92E-13	< 4.44E-04	< 3.09E-03	< 1.65E-13	> 1.28E+01
12*	2.01E+02	< 3.53E-03	< 7.77E-12	< 8.27E-13	< 3.76E-04	< 3.47E-03	< 1.92E-12	> 1.17E+01
Mean:								< 3.75E-12 > 1.19E+01
Standard Deviation:								1.39E-12 2.47E-01

TABLE G-3. Radionuclide and stable metal leaching data for Brunswick-1 cation resin waste-form specimen leached in synthetic Barnwell groundwater with pH 4.2. (continued)

Co-60

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.61E-02	1.44E-04	8.95E-11	1.96E-13	3.17E-07	3.17E-07	1.26E-17	1.69E+01
2*	2.96E-01	1.65E-04	2.51E-11	5.51E-14	3.62E-07	6.79E-07	8.08E-18	1.71E+01
3*	1.01E+00	3.39E-04	1.78E-11	3.91E-14	7.44E-07	1.42E-06	1.39E-17	1.69E+01
4*	2.01E+00	3.92E-04	1.56E-11	3.41E-14	8.60E-07	2.28E-06	2.58E-17	1.66E+01
5*	3.01E+00	4.24E-04	1.80E-11	3.94E-14	9.30E-07	3.21E-06	5.85E-17	1.62E+01
6*	4.01E+00	2.45E-04	1.04E-11	2.28E-14	5.38E-07	3.75E-06	2.75E-17	1.66E+01
7*	5.01E+00	2.82E-04	1.19E-11	2.60E-14	6.18E-07	4.37E-06	4.63E-17	1.63E+01
8*	1.81E+01	4.25E-04	1.38E-12	3.02E-15	9.33E-07	5.30E-06	1.46E-18	1.78E+01
9*	4.59E+01	6.06E-04	9.26E-13	2.03E-15	1.33E-06	6.63E-06	1.90E-18	1.77E+01
10*	9.10E+01	4.52E-04	4.24E-13	9.30E-16	9.91E-07	7.62E-06	8.75E-19	1.81E+01
11*	1.70E+02	4.03E-04	2.65E-13	5.82E-16	8.84E-07	8.51E-06	6.56E-19	1.82E+01
12*	2.01E+02	2.25E-04	4.94E-13	1.08E-15	4.92E-07	9.00E-06	3.30E-18	1.75E+01
=====								
Mean:			1.60E-11	3.50E-14			1.67E-17	1.72E+01
Standard Deviation:			7.13E-12	1.56E-14			5.55E-18	1.97E+01

Ni-63

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.61E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.96E-01	2.73E-03	4.15E-10	4.68E-12	3.07E-05	NA	5.83E-14	1.32E+01
3*	1.01E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.01E+00	5.75E-03	2.28E-10	2.57E-12	6.48E-05	NA	1.46E-13	1.28E+01
5*	3.01E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.01E+00	4.30E-03	1.82E-10	2.05E-12	4.84E-05	NA	2.23E-13	1.27E+01
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.81E+01	4.25E-03	1.38E-11	1.55E-13	4.79E-05	NA	3.86E-15	1.44E+01
9*	4.59E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.10E+01	3.08E-03	2.89E-12	3.25E-14	3.47E-05	NA	1.07E-15	1.50E+01
11*	1.70E+02	NA	NA	NA	NA	NA	NA	NA
12*	2.01E+02	NA	NA	NA	NA	NA	NA	NA
=====								
(90 days) Mean:			1.68E-10	1.90E-12			8.65E-14	1.36E+01
Standard Deviation:			7.62E-11	8.58E-13			4.31E-14	4.56E-01

Zn-65

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.61E-02	< 1.09E-04	< 6.76E-11	< 1.12E-11	< 1.81E-05	< 1.81E-05	< 4.09E-14	> 1.34E+01
2*	2.96E-01	< 1.19E-04	< 1.81E-11	< 2.99E-12	< 1.97E-05	< 3.77E-05	< 2.38E-14	> 1.36E+01
3*	1.01E+00	< 1.87E-04	< 9.84E-12	< 1.63E-12	< 3.10E-05	< 6.87E-05	< 2.41E-14	> 1.36E+01
4*	2.01E+00	< 1.88E-04	< 7.44E-12	< 1.23E-12	< 3.11E-05	< 9.98E-05	< 3.37E-14	> 1.35E+01
5*	3.01E+00	< 2.04E-04	< 8.63E-12	< 1.43E-12	< 3.37E-05	< 1.33E-04	< 7.69E-14	> 1.31E+01
6*	4.01E+00	< 2.97E-04	< 1.26E-11	< 2.08E-12	< 4.92E-05	< 1.83E-04	< 2.30E-13	> 1.26E+01
7*	5.01E+00	< 3.47E-04	< 1.46E-11	< 2.42E-12	< 5.75E-05	< 2.40E-04	< 4.00E-13	> 1.24E+01
8*	1.81E+01	< 1.41E-04	< 4.56E-13	< 7.55E-14	< 2.33E-05	< 2.63E-04	< 9.14E-16	> 1.50E+01
9*	4.59E+01	< 4.05E-04	< 6.19E-13	< 1.02E-13	< 6.71E-05	< 3.31E-04	< 4.84E-15	> 1.43E+01
10*	9.10E+01	< 1.41E-04	< 1.33E-13	< 2.19E-14	< 2.34E-05	< 3.54E-04	< 4.87E-16	> 1.53E+01
11*	1.70E+02	< 3.01E-04	< 1.98E-13	< 3.28E-14	< 4.98E-05	< 4.04E-04	< 2.08E-15	> 1.47E+01
12*	2.01E+02	< 1.63E-04	< 3.58E-13	< 5.92E-14	< 2.69E-05	< 4.31E-04	< 9.87E-15	> 1.40E+01
=====								
Mean:			< 1.17E-11	< 1.94E-12			< 7.06E-14	> 1.38E+01
Standard Deviation:			5.40E-12	8.93E-13			3.51E-14	2.62E-01

TABLE G-3. Radionuclide and stable metal leaching data for Brunswick-1 cation resin waste-form specimen leached in synthetic Barnwell groundwater with pH 4.2. (continued)

Sr-90

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.61E-02	1.56E-05	9.68E-12	3.90E-11	6.30E-05	6.30E-05	4.99E-13	1.23E+01
2*	2.96E-01	2.22E-05	3.38E-12	1.36E-11	8.96E-05	1.53E-04	4.95E-13	1.23E+01
3*	1.01E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.01E+00	1.60E-05	6.32E-13	2.55E-12	6.44E-05	NA	1.45E-13	1.28E+01
5*	3.01E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.01E+00	3.25E-05	1.38E-12	5.55E-12	1.31E-04	NA	1.63E-12	1.18E+01
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.81E+01	3.20E-05	1.04E-13	4.18E-13	1.29E-04	NA	2.80E-14	1.36E+01
9*	4.59E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.10E+01	6.34E-06	5.96E-15	2.40E-14	2.56E-05	NA	5.84E-16	1.52E+01
11*	1.70E+02	NA	NA	NA	NA	NA	NA	NA
12*	2.01E+02	NA	NA	NA	NA	NA	NA	NA
(90 days)			Mean:	2.53E-12	1.02E-11		4.66E-13	1.30E+01
Standard Deviation:				1.52E-12	6.12E-12		2.50E-13	5.09E-01

Sb-125

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.61E-02	< 1.04E-04	< 6.41E-11	< 2.91E-10	< 4.70E-04	< 4.70E-04	< 2.77E-11	> 1.06E+01
2*	2.96E-01	< 8.90E-05	< 1.35E-11	< 6.15E-11	< 4.04E-04	< 8.74E-04	< 1.01E-11	> 1.10E+01
3*	1.01E+00	< 1.13E-04	< 5.92E-12	< 2.69E-11	< 5.11E-04	< 1.39E-03	< 6.57E-12	> 1.12E+01
4*	2.01E+00	< 1.44E-04	< 5.70E-12	< 2.59E-11	< 6.52E-04	< 2.04E-03	< 1.49E-11	> 1.08E+01
5*	3.01E+00	< 8.33E-05	< 3.53E-12	< 1.60E-11	< 3.78E-04	< 2.42E-03	< 9.69E-12	> 1.10E+01
6*	4.01E+00	< 1.89E-04	< 8.02E-12	< 3.64E-11	< 8.60E-04	< 3.28E-03	< 7.03E-11	> 1.02E+01
7*	5.01E+00	< 1.04E-04	< 4.40E-12	< 2.00E-11	< 4.74E-04	< 3.75E-03	< 2.72E-11	> 1.06E+01
8*	1.81E+01	< 8.95E-05	< 2.90E-13	< 1.32E-12	< 4.06E-04	< 4.16E-03	< 2.78E-13	> 1.26E+01
9*	4.59E+01	< 1.95E-04	< 2.97E-13	< 1.35E-12	< 8.84E-04	< 5.04E-03	< 8.41E-13	> 1.21E+01
10*	9.10E+01	< 8.23E-05	< 7.73E-14	< 3.51E-13	< 3.73E-04	< 5.41E-03	< 1.24E-13	> 1.29E+01
11*	1.70E+02	< 1.05E-04	< 6.94E-14	< 3.15E-13	< 4.79E-04	< 5.89E-03	< 1.92E-13	> 1.27E+01
12*	2.01E+02	< 1.05E-04	< 2.32E-13	< 1.05E-12	< 4.79E-04	< 6.37E-03	< 3.12E-12	> 1.15E+01
Mean:			< 8.85E-12	< 4.02E-11			< 1.42E-11	> 1.14E+01
Standard Deviation:			5.16E-12	2.34E-11			5.83E-12	2.67E-01

Cs-134

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.61E-02	6.04E-05	3.74E-11	6.79E-10	1.10E-03	1.10E-03	1.51E-10	9.82E+00
2*	2.96E-01	1.86E-04	2.84E-11	5.15E-10	3.38E-03	4.48E-03	7.06E-10	9.15E+00
3*	1.01E+00	2.42E-04	1.27E-11	2.31E-10	4.39E-03	8.87E-03	4.86E-10	9.31E+00
4*	2.01E+00	2.22E-04	8.78E-12	1.59E-10	4.02E-03	1.29E-02	5.65E-10	9.25E+00
5*	3.01E+00	1.13E-04	4.78E-12	8.68E-11	2.05E-03	1.49E-02	2.84E-10	9.55E+00
6*	4.01E+00	1.20E-04	5.10E-12	9.25E-11	2.18E-03	1.71E-02	4.54E-10	9.34E+00
7*	5.01E+00	1.09E-04	4.57E-12	8.29E-11	1.97E-03	1.91E-02	4.70E-10	9.33E+00
8*	1.81E+01	9.78E-05	3.17E-13	5.75E-12	1.77E-03	2.09E-02	5.30E-12	1.13E+01
9*	4.59E+01	< 7.56E-05	< 1.15E-13	< 2.09E-12	< 1.37E-03	< 2.22E-02	< 2.02E-12	> 1.17E+01
10*	9.10E+01	< 5.24E-05	< 4.92E-14	< 8.94E-13	< 9.51E-04	< 2.32E-02	< 8.07E-13	> 1.21E+01
11*	1.70E+02	< 6.47E-05	< 4.26E-14	< 7.73E-13	< 1.18E-03	< 2.44E-02	< 1.16E-12	> 1.19E+01
12*	2.01E+02	< 3.84E-05	< 8.44E-14	< 1.53E-12	< 6.97E-04	< 2.51E-02	< 6.61E-12	> 1.12E+01
Mean:			< 8.53E-12	< 1.55E-10			< 2.61E-10	> 1.03E+01
Standard Deviation:			3.53E-12	6.40E-11			7.62E-11	3.44E-01

TABLE G-3. Radionuclide and stable metal leaching data for Brunswick-1 cation resin waste-form specimen leached in synthetic Barnwell groundwater with pH 4.2. (continued)

Cs-137

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.61E-02	1.66E-03	1.03E-09	4.28E-10	6.90E-04	6.90E-04	5.98E-11	1.02E+01
2*	2.96E-01	2.40E-03	3.66E-10	1.52E-10	9.98E-04	1.69E-03	6.14E-11	1.02E+01
3*	1.01E+00	4.85E-03	2.55E-10	1.06E-10	2.02E-03	3.70E-03	1.02E-10	9.99E+00
4*	2.01E+00	5.34E-03	2.12E-10	8.80E-11	2.22E-03	5.92E-03	1.72E-10	9.76E+00
5*	3.01E+00	3.74E-03	1.59E-10	6.59E-11	1.56E-03	7.48E-03	1.64E-10	9.79E+00
6*	4.01E+00	2.92E-03	1.23E-10	5.13E-11	1.21E-03	8.69E-03	1.39E-10	9.86E+00
7*	5.01E+00	1.87E-03	7.87E-11	3.27E-11	7.77E-04	9.47E-03	7.30E-11	1.01E+01
8*	1.81E+01	2.60E-03	8.43E-12	3.50E-12	1.08E-03	1.05E-02	1.96E-12	1.17E+01
9*	4.59E+01	1.64E-03	2.51E-12	1.04E-12	6.82E-04	1.12E-02	5.00E-13	1.23E+01
10*	9.10E+01	6.29E-04	5.91E-13	2.45E-13	2.61E-04	1.15E-02	6.08E-14	1.32E+01
11*	1.70E+02	3.97E-04	2.61E-13	1.09E-13	1.65E-04	1.17E-02	2.29E-14	1.36E+01
12*	2.01E+02	2.06E-04	4.53E-13	1.88E-13	8.56E-05	1.17E-02	9.98E-14	1.30E+01
Mean:			1.86E-10	7.74E-11			6.45E-11	1.12E+01
Standard Deviation:			8.41E-11	3.49E-11			1.93E-11	4.36E-01

Pu-241

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.61E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.96E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.01E+00	1.52E-05	7.98E-13	2.26E-12	4.30E-05	NA	4.65E-14	1.33E+01
4*	2.01E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.01E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.01E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.59E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
Mean:			NA	NA			NA	NA
Standard Deviation:			NA	NA			NA	NA

Fe

SAMPLE NUMBER	TOTAL TIME (days)	QUANTITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.61E-02	< 7.39E+02	< 4.58E-04	< 4.15E-10	< 6.70E-04	< 6.70E-04	< 5.63E-11	> 1.02E+01
2*	2.96E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.01E+00	< 8.10E+02	< 4.26E-05	< 3.86E-11	< 7.34E-04	NA	< 1.36E-11	> 1.09E+01
4*	2.01E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.01E+00	< 7.28E+02	< 3.08E-05	< 2.80E-11	< 6.60E-04	NA	< 2.95E-11	> 1.05E+01
6*	4.01E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.01E+00	< 7.99E+02	< 3.36E-05	< 3.05E-11	< 7.24E-04	NA	< 6.35E-11	> 1.02E+01
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.59E+01	< 7.88E+02	< 1.20E-06	< 1.09E-12	< 7.14E-04	NA	< 5.48E-13	> 1.23E+01
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
(90 days)		Mean:	< 1.13E-04	< 1.03E-10			< 3.27E-11	> 1.08E+01
		Standard Deviation:	8.64E-05	7.83E-11			1.21E-11	3.79E-01

TABLE G-3. Radionuclide and stable metal leaching data for Brunswick-1 cation resin waste-form specimen leached in synthetic Barnwell groundwater with pH 4.2. (continued)

Ni

SAMPLE NUMBER	TOTAL TIME (days)	QUANTITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.61E-02	< 3.94E+02	< 2.44E-04	< 1.95E-09	< 3.15E-03	< 3.15E-03	< 1.25E-09	> 8.90E+00
2*	2.96E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.01E+00	< 4.32E+02	< 2.27E-05	< 1.82E-10	< 3.46E-03	NA	< 3.01E-10	> 9.52E+00
4*	2.01E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.01E+00	< 3.88E+02	< 1.64E-05	< 1.32E-10	< 3.11E-03	NA	< 6.53E-10	> 9.18E+00
6*	4.01E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.01E+00	< 4.26E+02	< 1.79E-05	< 1.44E-10	< 3.41E-03	NA	< 1.41E-09	> 8.85E+00
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.59E+01	< 4.20E+02	< 6.41E-07	< 5.13E-12	< 3.36E-03	NA	< 1.22E-11	> 1.09E+01
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
=====								
(90 days)		Mean:	< 6.04E-05	< 4.83E-10			< 7.24E-10	> 9.48E+00
		Standard Deviation:	4.61E-05	3.69E-10			2.68E-10	3.79E-01

Co

SAMPLE NUMBER	TOTAL TIME (days)	QUANTITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.61E-02	< 4.93E+02	< 3.05E-04	< 8.52E-09	< 1.38E-02	< 1.38E-02	< 2.38E-08	> 7.62E+00
2*	2.96E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.01E+00	< 5.40E+02	< 2.84E-05	< 7.94E-10	< 1.51E-02	NA	< 5.72E-09	> 8.24E+00
4*	2.01E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.01E+00	< 4.85E+02	< 2.06E-05	< 5.74E-10	< 1.35E-02	NA	< 1.24E-08	> 7.91E+00
6*	4.01E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.01E+00	< 5.33E+02	< 2.24E-05	< 6.26E-10	< 1.49E-02	NA	< 2.68E-08	> 7.57E+00
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.59E+01	< 5.25E+02	< 8.01E-07	< 2.24E-11	< 1.47E-02	NA	< 2.31E-10	> 9.64E+00
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
=====								
(90 days)		Mean:	< 7.55E-05	< 2.11E-09			< 1.38E-08	> 8.20E+00
		Standard Deviation:	5.76E-05	1.61E-09			5.10E-09	3.79E-01

Cr

SAMPLE NUMBER	TOTAL TIME (days)	QUANTITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.61E-02	< 9.85E+01	< 6.10E-05	< 7.90E-10	< 1.27E-03	< 1.27E-03	< 2.04E-10	> 9.69E+00
2*	2.96E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.01E+00	< 1.08E+02	< 5.68E-06	< 7.36E-11	< 1.40E-03	NA	< 4.91E-11	> 1.03E+01
4*	2.01E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.01E+00	< 9.70E+01	< 4.11E-06	< 5.32E-11	< 1.26E-03	NA	< 1.07E-10	> 9.97E+00
6*	4.01E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.01E+00	< 1.07E+02	< 4.48E-06	< 5.80E-11	< 1.38E-03	NA	< 2.30E-10	> 9.64E+00
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.59E+01	< 1.05E+02	< 1.60E-07	< 2.07E-12	< 1.36E-03	NA	< 1.99E-12	> 1.17E+01
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
=====								
(90 days)		Mean:	< 1.51E-05	< 1.95E-10			< 1.18E-10	> 1.03E+01
		Standard Deviation:	1.15E-05	1.49E-10			4.37E-11	3.79E-01

TABLE G-4. Radionuclide and stable metal leaching data for Brunswick-1 cation resin waste-form specimen leached synthetic Hanford ground water with pH 8.9.

Mn-54

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.96E-02	< 9.29E-05	< 5.45E-11	< 6.11E-13	< 1.04E-06	< 1.04E-06	< 1.33E-16	> 1.59E+01
2*	2.99E-01	< 9.11E-05	< 1.37E-11	< 1.54E-13	< 1.02E-06	< 2.06E-06	< 6.75E-17	> 1.62E+01
3*	1.01E+00	< 6.46E-05	< 3.15E-12	< 3.53E-14	< 7.24E-07	< 2.79E-06	< 1.19E-17	> 1.69E+01
4*	2.01E+00	< 6.17E-05	< 2.14E-12	< 2.40E-14	< 6.92E-07	< 3.48E-06	< 1.34E-17	> 1.69E+01
5*	3.01E+00	< 1.00E-04	< 3.52E-12	< 3.94E-14	< 1.12E-06	< 4.60E-06	< 6.13E-17	> 1.62E+01
6*	4.03E+00	< 1.12E-04	< 3.85E-12	< 4.31E-14	< 1.26E-06	< 5.86E-06	< 1.03E-16	> 1.60E+01
7*	5.04E+00	< 3.81E-04	< 1.32E-11	< 1.48E-13	< 4.28E-06	< 1.01E-05	< 1.58E-15	> 1.48E+01
8*	1.80E+01	< 7.93E-05	< 2.15E-13	< 2.40E-15	< 8.89E-07	< 1.10E-05	< 9.67E-19	> 1.80E+01
9*	4.52E+01	< 6.73E-05	< 9.78E-14	< 1.10E-15	< 7.55E-07	< 1.18E-05	< 5.74E-19	> 1.82E+01
10*	9.03E+01	< 6.72E-05	< 6.47E-14	< 7.26E-16	< 7.53E-07	< 1.25E-05	< 5.51E-19	> 1.83E+01
11*	1.69E+02	< 1.05E-04	< 6.04E-14	< 6.77E-16	< 1.17E-06	< 1.37E-05	< 9.22E-19	> 1.80E+01
12*	2.00E+02	< 8.94E-05	< 1.40E-13	< 1.56E-15	< 1.00E-06	< 1.47E-05	< 7.17E-18	> 1.71E+01
Mean: < 7.90E-12 < 8.85E-14								< 1.65E-16 > 1.69E+01
Standard Deviation: 4.47E-12 5.01E-14								1.29E-16 3.20E-01

Fe-55

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.96E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.99E-01	1.80E-04	2.72E-11	5.77E-14	3.82E-07	NA	9.46E-18	1.70E+01
3*	1.01E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.01E+00	3.23E-03	1.12E-10	2.38E-13	6.85E-06	NA	1.31E-15	1.49E+01
5*	3.01E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.03E+00	3.02E-04	1.04E-11	2.20E-14	6.41E-07	NA	2.69E-17	1.66E+01
7*	5.04E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.80E+01	1.81E-04	4.90E-13	1.04E-15	3.84E-07	NA	1.81E-19	1.87E+01
9*	4.52E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.03E+01	2.61E-03	2.52E-12	5.34E-15	5.54E-06	NA	2.99E-17	1.65E+01
11*	1.69E+02	NA	NA	NA	NA	NA	NA	NA
12*	2.00E+02	NA	NA	NA	NA	NA	NA	NA
(90 days) Mean: 3.05E-11 6.47E-14								2.76E-16 1.67E+01
Standard Deviation: 2.09E-11 4.43E-14								2.60E-16 6.17E-01

Co-58

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.96E-02	< 2.91E-03	< 1.71E-09	< 1.86E-10	< 3.16E-04	< 3.16E-04	< 1.23E-11	> 1.09E+01
2*	2.99E-01	< 1.52E-03	< 2.30E-10	< 2.50E-11	< 1.65E-04	< 4.82E-04	< 1.77E-12	> 1.18E+01
3*	1.01E+00	< 1.66E-03	< 8.09E-11	< 8.80E-12	< 1.81E-04	< 6.62E-04	< 7.41E-13	> 1.21E+01
4*	2.01E+00	< 2.11E-03	< 7.31E-11	< 7.95E-12	< 2.29E-04	< 8.92E-04	< 1.47E-12	> 1.18E+01
5*	3.01E+00	< 1.63E-03	< 5.73E-11	< 6.23E-12	< 1.78E-04	< 1.07E-03	< 1.53E-12	> 1.18E+01
6*	4.03E+00	< 2.36E-03	< 8.11E-11	< 8.83E-12	< 2.57E-04	< 1.33E-03	< 4.33E-12	> 1.14E+01
7*	5.04E+00	< 2.05E-03	< 7.10E-11	< 7.72E-12	< 2.23E-04	< 1.55E-03	< 4.28E-12	> 1.14E+01
8*	1.80E+01	< 2.96E-03	< 8.02E-12	< 8.72E-13	< 3.22E-04	< 1.87E-03	< 1.27E-13	> 1.29E+01
9*	4.52E+01	< 1.52E-03	< 2.20E-12	< 2.40E-13	< 1.65E-04	< 2.04E-03	< 2.75E-14	> 1.36E+01
10*	9.03E+01	< 1.87E-03	< 1.81E-12	< 1.96E-13	< 2.04E-04	< 2.24E-03	< 4.04E-14	> 1.34E+01
11*	1.69E+02	< 3.45E-03	< 1.99E-12	< 2.17E-13	< 3.76E-04	< 2.62E-03	< 9.46E-14	> 1.30E+01
12*	2.00E+02	< 4.07E-03	< 6.35E-12	< 6.91E-13	< 4.43E-04	< 3.06E-03	< 1.40E-12	> 1.19E+01
Mean: < 1.93E-10 < 2.10E-11								< 2.34E-12 > 1.22E+01
Standard Deviation: 1.39E-10 1.51E-11								9.99E-13 2.47E-01

TABLE G-4. Radionuclide and stable metal leaching data for Brunswick-1 cation resin waste-form specimen leached synthetic Hanford ground water with pH 8.9. (continued)

Co-60

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.96E-02	8.53E-05	5.01E-11	1.12E-13	1.91E-07	1.91E-07	4.48E-18	1.73E+01
2*	2.99E-01	2.00E-04	3.02E-11	6.77E-14	4.48E-07	6.39E-07	1.30E-17	1.89E+01
3*	1.01E+00	3.93E-04	1.92E-11	4.30E-14	8.82E-07	1.52E-06	1.77E-17	1.68E+01
4*	2.01E+00	3.72E-04	1.29E-11	2.89E-14	8.33E-07	2.35E-06	1.94E-17	1.67E+01
5*	3.01E+00	3.74E-04	1.31E-11	2.94E-14	8.38E-07	3.19E-06	3.41E-17	1.65E+01
6*	4.03E+00	2.91E-04	1.00E-11	2.24E-14	6.53E-07	3.84E-06	2.79E-17	1.66E+01
7*	5.04E+00	1.65E-03	5.72E-11	1.28E-13	3.70E-06	7.54E-06	1.18E-15	1.49E+01
8*	1.80E+01	8.39E-04	2.27E-12	5.09E-15	1.88E-06	9.42E-06	4.33E-18	1.74E+01
9*	4.52E+01	5.17E-04	7.51E-13	1.68E-15	1.16E-06	1.06E-05	1.36E-18	1.79E+01
10*	9.03E+01	5.82E-04	5.61E-13	1.26E-15	1.31E-06	1.19E-05	1.66E-18	1.78E+01
11*	1.69E+02	5.41E-04	3.12E-13	6.99E-16	1.21E-06	1.31E-05	9.85E-19	1.80E+01
12*	2.00E+02	3.34E-04	5.21E-13	1.17E-15	7.48E-07	1.38E-05	3.99E-18	1.74E+01
Mean:			1.64E-11	3.68E-14			1.09E-16	1.70E+01
Standard Deviation:			5.69E-12	1.27E-14			9.75E-17	2.42E-01

Ni-63

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.96E-02	7.06E-03	4.15E-09	4.78E-11	8.13E-05	8.13E-05	8.11E-13	1.21E+01
2*	2.99E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.01E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.01E+00	6.20E-04	2.15E-11	2.47E-13	7.14E-06	NA	1.43E-15	1.48E+01
5*	3.01E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.03E+00	1.87E-02	6.41E-10	7.38E-12	2.15E-04	NA	3.03E-12	1.15E+01
7*	5.04E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.80E+01	2.72E-04	7.35E-13	8.46E-15	3.13E-06	NA	1.20E-17	1.69E+01
9*	4.52E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.03E+01	1.41E-03	1.36E-12	1.56E-14	1.62E-05	NA	2.55E-16	1.56E+01
11*	1.69E+02	NA	NA	NA	NA	NA	NA	NA
12*	2.00E+02	NA	NA	NA	NA	NA	NA	NA
(90 days) Mean:			9.63E-10	1.11E-11			7.68E-13	1.42E+01
Standard Deviation:			8.06E-10	9.28E-12			5.86E-13	1.03E+00

Zn-65

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.96E-02	< 1.27E-04	< 7.47E-11	< 1.26E-11	< 2.15E-05	< 2.15E-05	< 5.68E-14	> 1.32E+01
2*	2.99E-01	< 1.19E-04	< 1.80E-11	< 3.05E-12	< 2.02E-05	< 4.17E-05	< 2.64E-14	> 1.36E+01
3*	1.01E+00	< 1.57E-04	< 7.67E-12	< 1.30E-12	< 2.66E-05	< 6.83E-05	< 1.61E-14	> 1.38E+01
4*	2.01E+00	< 1.82E-04	< 6.30E-12	< 1.07E-12	< 3.08E-05	< 9.91E-05	< 2.65E-14	> 1.36E+01
5*	3.01E+00	< 1.29E-04	< 4.51E-12	< 7.63E-13	< 2.18E-05	< 1.21E-04	< 2.30E-14	> 1.36E+01
6*	4.03E+00	< 3.83E-04	< 1.32E-11	< 2.23E-12	< 6.49E-05	< 1.86E-04	< 2.76E-13	> 1.26E+01
7*	5.04E+00	< 1.61E-04	< 5.59E-12	< 9.47E-13	< 2.73E-05	< 2.13E-04	< 6.44E-14	> 1.32E+01
8*	1.80E+01	< 3.34E-04	< 9.05E-13	< 1.53E-13	< 5.66E-05	< 2.70E-04	< 3.92E-15	> 1.44E+01
9*	4.52E+01	< 1.96E-04	< 2.84E-13	< 4.81E-14	< 3.31E-05	< 3.03E-04	< 1.10E-15	> 1.50E+01
10*	9.03E+01	< 1.45E-04	< 1.39E-13	< 2.36E-14	< 2.45E-05	< 3.27E-04	< 5.82E-16	> 1.52E+01
11*	1.69E+02	< 1.66E-04	< 9.58E-14	< 1.62E-14	< 2.81E-05	< 3.55E-04	< 5.29E-16	> 1.53E+01
12*	2.00E+02	< 2.90E-04	< 4.53E-13	< 7.67E-14	< 4.91E-05	< 4.04E-04	< 1.73E-14	> 1.38E+01
Mean:			< 1.10E-11	< 1.86E-12			< 4.27E-14	> 1.39E+01
Standard Deviation:			6.02E-12	1.02E-12			2.20E-14	2.47E-01

TABLE G-4. Radionuclide and stable metal leaching data for Brunswick-1 cation resin waste-form specimen leached synthetic Hanford ground water with pH 8.9. (continued)

Sr-90

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.96E-02	1.32E-05	7.77E-12	3.21E-11	5.46E-05	5.46E-05	3.65E-13	1.24E+01
2*	2.99E-01	< 4.37E-06	< 6.59E-13	< 2.72E-12	< 1.80E-05	< 7.26E-05	< 2.10E-14	> 1.37E+01
3*	1.01E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.01E+00	1.35E-05	4.66E-13	1.92E-12	5.55E-05	NA	8.62E-14	1.31E+01
5*	3.01E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.03E+00	6.78E-05	2.33E-12	9.60E-12	2.80E-04	NA	5.12E-12	1.13E+01
7*	5.04E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.80E+01	1.68E-05	4.55E-14	1.88E-13	6.93E-05	NA	5.88E-15	1.42E+01
9*	4.52E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.03E+01	9.22E-05	8.89E-14	3.67E-13	3.80E-04	NA	1.41E-13	1.29E+01
11*	1.69E+02	NA	NA	NA	NA	NA	NA	NA
12*	2.00E+02	NA	NA	NA	NA	NA	NA	NA
=====								
(90 days)		Mean:	1.89E-12	7.81E-12			9.57E-13	1.29E+01
Standard Deviation:			1.22E-12	5.05E-12			8.35E-13	4.16E-01

Sb-125

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.96E-02	< 1.32E-04	< 7.77E-11	< 3.61E-10	< 6.14E-04	< 6.14E-04	< 4.63E-11	> 1.03E+01
2*	2.99E-01	< 8.65E-05	< 1.31E-11	< 6.06E-11	< 4.02E-04	< 1.02E-03	< 1.05E-11	> 1.10E+01
3*	1.01E+00	< 1.04E-04	< 5.08E-12	< 2.36E-11	< 4.84E-04	< 1.50E-03	< 5.32E-12	> 1.13E+01
4*	2.01E+00	< 1.21E-04	< 4.18E-12	< 1.94E-11	< 5.60E-04	< 2.06E-03	< 8.76E-12	> 1.11E+01
5*	3.01E+00	< 1.68E-04	< 5.88E-12	< 2.73E-11	< 7.78E-04	< 2.84E-03	< 2.94E-11	> 1.05E+01
6*	4.03E+00	< 1.09E-04	< 3.76E-12	< 1.74E-11	< 5.08E-04	< 3.35E-03	< 1.69E-11	> 1.08E+01
7*	5.04E+00	< 1.31E-04	< 4.54E-12	< 2.11E-11	< 6.08E-04	< 3.95E-03	< 3.19E-11	> 1.05E+01
8*	1.80E+01	< 8.19E-05	< 2.22E-13	< 1.03E-12	< 3.80E-04	< 4.33E-03	< 1.77E-13	> 1.28E+01
9*	4.52E+01	< 1.16E-04	< 1.68E-13	< 7.79E-13	< 5.36E-04	< 4.87E-03	< 2.90E-13	> 1.25E+01
10*	9.03E+01	< 1.03E-04	< 9.96E-14	< 4.62E-13	< 4.80E-04	< 5.35E-03	< 2.23E-13	> 1.27E+01
11*	1.69E+02	< 9.27E-05	< 5.35E-14	< 2.48E-13	< 4.30E-04	< 5.78E-03	< 1.24E-13	> 1.29E+01
12*	2.00E+02	< 1.47E-04	< 2.29E-13	< 1.06E-12	< 6.82E-04	< 6.46E-03	< 3.32E-12	> 1.15E+01
=====								
Mean:			< 9.58E-12	< 4.45E-11			< 1.28E-11	> 1.15E+01
Standard Deviation:			6.29E-12	2.92E-11			4.42E-12	2.79E-01

Cs-134

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.96E-02	1.01E-04	5.96E-11	1.11E-09	1.88E-03	1.88E-03	4.35E-10	9.36E+00
2*	2.99E-01	< 1.16E-04	< 1.76E-11	< 3.26E-10	< 2.16E-03	< 4.04E-03	< 3.02E-10	> 9.52E+00
3*	1.01E+00	2.20E-04	1.07E-11	1.99E-10	4.07E-03	< 8.11E-03	3.77E-10	9.42E+00
4*	2.01E+00	1.76E-04	6.09E-12	1.13E-10	3.26E-03	< 1.14E-02	2.98E-10	9.53E+00
5*	3.01E+00	1.48E-04	5.19E-12	9.63E-11	2.75E-03	< 1.41E-02	3.66E-10	9.44E+00
6*	4.03E+00	9.92E-05	3.41E-12	6.32E-11	1.84E-03	< 1.60E-02	2.22E-10	9.65E+00
7*	5.04E+00	< 4.45E-05	< 1.54E-12	< 2.86E-11	< 8.26E-04	< 1.68E-02	< 5.89E-11	> 1.02E+01
8*	1.80E+01	5.11E-05	1.38E-13	2.56E-12	9.48E-04	< 1.77E-02	1.10E-12	1.20E+01
9*	4.52E+01	4.75E-05	6.89E-14	1.28E-12	8.81E-04	< 1.86E-02	7.81E-13	1.21E+01
10*	9.03E+01	< 4.32E-05	< 4.17E-14	< 7.73E-13	< 8.02E-04	< 1.94E-02	< 6.25E-13	> 1.22E+01
11*	1.69E+02	< 6.70E-05	< 3.87E-14	< 7.17E-13	< 1.24E-03	< 2.07E-02	< 1.04E-12	> 1.20E+01
12*	2.00E+02	< 3.98E-05	< 6.22E-14	< 1.15E-12	< 7.39E-04	< 2.14E-02	< 3.90E-12	> 1.14E+01
=====								
Mean:			< 8.70E-12	< 1.61E-10			< 1.72E-10	> 1.06E+01
Standard Deviation:			4.88E-12	9.05E-11			5.09E-11	3.58E-01

TABLE G-4. Radionuclide and stable metal leaching data for Brunswick-1 cation resin waste-form specimen leached synthetic Hanford ground water with pH 8.9. (continued)

Cs-137

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.96E-02	2.09E-03	1.23E-09	5.21E-10	8.86E-04	8.86E-04	9.64E-11	1.00E+01
2*	2.99E-01	4.18E-03	6.32E-10	2.68E-10	1.78E-03	2.66E-03	2.05E-10	9.69E+00
3*	1.01E+00	6.71E-03	3.27E-10	1.39E-10	2.85E-03	5.51E-03	1.85E-10	9.73E+00
4*	2.01E+00	5.32E-03	1.84E-10	7.83E-11	2.26E-03	7.77E-03	1.43E-10	9.85E+00
5*	3.01E+00	3.75E-03	1.32E-10	5.59E-11	1.59E-03	9.37E-03	1.23E-10	9.91E+00
6*	4.03E+00	2.39E-03	8.19E-11	3.48E-11	1.01E-03	1.04E-02	6.73E-11	1.02E+01
7*	5.04E+00	1.53E-03	5.30E-11	2.25E-11	6.49E-04	1.10E-02	3.64E-11	1.04E+01
8*	1.80E+01	1.32E-03	3.57E-12	1.52E-12	5.61E-04	1.16E-02	3.85E-13	1.24E+01
9*	4.52E+01	9.32E-04	1.35E-12	5.75E-13	3.96E-04	1.20E-02	1.58E-13	1.28E+01
10*	9.03E+01	5.79E-04	5.58E-13	2.37E-13	2.46E-04	1.22E-02	5.87E-14	1.32E+01
11*	1.69E+02	2.76E-04	1.59E-13	6.76E-14	1.17E-04	1.23E-02	9.20E-15	1.40E+01
12*	2.00E+02	1.76E-04	2.75E-13	1.17E-13	7.48E-05	1.24E-02	4.00E-14	1.34E+01
Mean:			2.20E-10	9.35E-11			7.13E-11	1.13E+01
Standard Deviation:			1.06E-10	4.51E-11			2.23E-11	4.91E-01

Pu-241

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.96E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.99E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.01E+00	2.52E-05	1.23E-12	3.55E-12	7.29E-05	NA	1.21E-13	1.29E+01
4*	2.01E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.01E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.03E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.04E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.80E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.52E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.03E+01	NA	NA	NA	NA	NA	NA	NA
Mean:			NA	NA			NA	NA
Standard Deviation:			NA	NA			NA	NA

Fe

SAMPLE NUMBER	TOTAL TIME (days)	QUANTITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.96E-02	< 7.84E+02	< 4.60E-04	< 4.27E-10	< 7.26E-04	< 7.26E-04	< 6.47E-11	> 1.02E+01
2*	2.99E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.01E+00	< 8.06E+02	< 3.93E-05	< 3.64E-11	< 7.47E-04	NA	< 1.27E-11	> 1.09E+01
4*	2.01E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.01E+00	< 7.54E+02	< 2.64E-05	< 2.45E-11	< 6.99E-04	NA	< 2.37E-11	> 1.06E+01
6*	4.03E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.04E+00	< 8.21E+02	< 2.85E-05	< 2.64E-11	< 7.61E-04	NA	< 5.00E-11	> 1.03E+01
8*	1.80E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.52E+01	< 7.88E+02	< 1.14E-06	< 1.06E-12	< 7.30E-04	NA	< 5.37E-13	> 1.23E+01
10*	9.03E+01	NA	NA	NA	NA	NA	NA	NA
(90 days) Mean:							< 3.03E-11	> 1.09E+01
Standard Deviation:							1.19E-11	3.75E-01

TABLE G-4. Radionuclide and stable metal leaching data for Brunswick-1 cation resin waste-form specimen leached synthetic Hanford ground water with pH 8.9. (continued)

Ni

SAMPLE NUMBER	TOTAL TIME (days)	QUANTITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.96E-02	< 4.18E+02	< 2.45E-04	< 2.02E-09	< 3.44E-03	< 3.44E-03	< 1.45E-09	> 8.84E+00
2*	2.99E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.01E+00	< 4.30E+02	< 2.10E-05	< 1.73E-10	< 3.54E-03	NA	< 2.85E-10	> 9.55E+00
4*	2.01E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.01E+00	< 4.02E+02	< 1.41E-05	< 1.16E-10	< 3.31E-03	NA	< 5.31E-10	> 9.27E+00
6*	4.03E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.04E+00	< 4.38E+02	< 1.52E-05	< 1.25E-10	< 3.60E-03	NA	< 1.12E-09	> 8.95E+00
8*	1.80E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.52E+01	< 4.20E+02	< 6.10E-07	< 5.02E-12	< 3.46E-03	NA	< 1.20E-11	> 1.09E+01
10*	9.03E+01	NA	NA	NA	NA	NA	NA	NA
=====								
(90 days)		Mean:	< 5.93E-05	< 4.88E-10			< 6.80E-10	> 9.51E+00
		Standard Deviation:	4.67E-05	3.84E-10			2.66E-10	3.75E-01

Co

SAMPLE NUMBER	TOTAL TIME (days)	QUANTITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.96E-02	< 5.23E+02	< 3.07E-04	< 8.76E-09	< 1.49E-02	< 1.49E-02	< 2.73E-08	> 7.56E+00
2*	2.99E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.01E+00	< 5.38E+02	< 2.62E-05	< 7.49E-10	< 1.54E-02	NA	< 5.36E-09	> 8.27E+00
4*	2.01E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.01E+00	< 5.03E+02	< 1.76E-05	< 5.03E-10	< 1.44E-02	NA	< 1.00E-08	> 8.00E+00
6*	4.03E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.04E+00	< 5.48E+02	< 1.90E-05	< 5.42E-10	< 1.56E-02	NA	< 2.11E-08	> 7.68E+00
8*	1.80E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.52E+01	< 5.25E+02	< 7.62E-07	< 2.18E-11	< 1.50E-02	NA	< 2.26E-10	> 9.64E+00
10*	9.03E+01	NA	NA	NA	NA	NA	NA	NA
=====								
(90 days)		Mean:	< 7.41E-05	< 2.12E-09			< 1.28E-08	> 8.23E+00
		Standard Deviation:	5.83E-05	1.67E-09			5.01E-09	3.75E-01

Cr

SAMPLE NUMBER	TOTAL TIME (days)	QUANTITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.96E-02	< 1.05E+02	< 6.14E-05	< 8.12E-10	< 1.38E-03	< 1.38E-03	< 2.35E-10	> 9.63E+00
2*	2.99E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.01E+00	< 1.08E+02	< 5.24E-06	< 6.94E-11	< 1.42E-03	NA	< 4.60E-11	> 1.03E+01
4*	2.01E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.01E+00	< 1.01E+02	< 3.52E-06	< 4.66E-11	< 1.33E-03	NA	< 8.58E-11	> 1.01E+01
6*	4.03E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.04E+00	< 1.09E+02	< 3.80E-06	< 5.02E-11	< 1.45E-03	NA	< 1.81E-10	> 9.74E+00
8*	1.80E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.52E+01	< 1.05E+02	< 1.52E-07	< 2.02E-12	< 1.39E-03	NA	< 1.94E-12	> 1.17E+01
10*	9.03E+01	NA	NA	NA	NA	NA	NA	NA
=====								
(90 days)		Mean:	< 1.48E-05	< 1.96E-10			< 1.10E-10	> 1.03E+01
		Standard Deviation:	1.17E-05	1.54E-10			4.30E-11	3.75E-01

TABLE G-5. Radionuclide and stable metal leaching data for Brunswick-1 cation resin waste-form specimen leached in synthetic seawater with pH 6.4.

Mn-54

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	< 7.23E-05	< 4.49E-11	< 4.94E-13	< 7.96E-07	< 7.96E-07	< 8.32E-17	> 1.61E+01
2*	3.06E-01	< 9.92E-05	< 2.36E-11	< 2.60E-13	< 1.09E-06	< 1.89E-06	< 1.93E-16	> 1.57E+01
3*	1.02E+00	< 5.34E-05	< 3.93E-12	< 4.33E-14	< 5.88E-07	< 2.48E-06	< 1.84E-17	> 1.67E+01
4*	2.02E+00	< 7.02E-05	< 3.69E-12	< 4.06E-14	< 7.72E-07	< 3.25E-06	< 3.91E-17	> 1.64E+01
5*	3.02E+00	< 7.02E-05	< 3.69E-12	< 4.06E-14	< 7.73E-07	< 4.02E-06	< 6.62E-17	> 1.62E+01
6*	4.03E+00	< 1.77E-04	< 9.26E-12	< 1.02E-13	< 1.94E-06	< 5.97E-06	< 5.85E-16	> 1.52E+01
7*	5.04E+00	< 1.27E-04	< 6.55E-12	< 7.21E-14	< 1.39E-06	< 7.36E-06	< 3.77E-16	> 1.54E+01
8*	1.81E+01	< 1.17E-04	< 4.72E-13	< 5.20E-15	< 1.29E-06	< 8.65E-06	< 4.59E-18	> 1.73E+01
9*	4.60E+01	< 9.24E-05	< 1.74E-13	< 1.92E-15	< 1.02E-06	< 9.67E-06	< 1.80E-18	> 1.77E+01
10*	9.10E+01	< 8.64E-05	< 1.01E-13	< 1.11E-15	< 9.51E-07	< 1.06E-05	< 1.32E-18	> 1.79E+01
11*	1.70E+02	< 1.20E-04	< 7.98E-14	< 8.79E-16	< 1.32E-06	< 1.19E-05	< 1.58E-18	> 1.78E+01
12*	2.01E+02	< 1.24E-04	< 2.11E-13	< 2.33E-15	< 1.36E-06	< 1.33E-05	< 1.61E-17	> 1.68E+01
Mean:								< 1.16E-16 > 1.66E+01
Standard Deviation:								5.33E-17 2.68E-01

Co-58

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	< 3.02E-03	< 1.88E-09	< 2.01E-10	< 3.23E-04	< 3.23E-04	< 1.37E-11	> 1.09E+01
2*	3.06E-01	8.89E-03	2.12E-09	2.26E-10	9.50E-04	< 1.27E-03	1.46E-10	9.83E+00
3*	1.02E+00	< 3.20E-03	< 2.35E-10	< 2.52E-11	< 3.41E-04	< 1.61E-03	< 6.21E-12	> 1.12E+01
4*	2.02E+00	< 2.06E-03	< 1.08E-10	< 1.16E-11	< 2.20E-04	< 1.83E-03	< 3.17E-12	> 1.15E+01
5*	3.02E+00	< 2.07E-03	< 1.09E-10	< 1.16E-11	< 2.21E-04	< 2.06E-03	< 5.41E-12	> 1.13E+01
6*	4.03E+00	< 3.04E-03	< 1.59E-10	< 1.70E-11	< 3.25E-04	< 2.38E-03	< 1.63E-11	> 1.08E+01
7*	5.04E+00	< 1.54E-03	< 7.98E-11	< 8.53E-12	< 1.65E-04	< 2.55E-03	< 5.29E-12	> 1.13E+01
8*	1.81E+01	< 1.94E-04	< 7.79E-13	< 8.33E-14	< 2.07E-05	< 2.57E-03	< 1.18E-15	> 1.49E+01
9*	4.60E+01	< 3.41E-03	< 6.43E-12	< 6.87E-13	< 3.64E-04	< 2.93E-03	< 2.31E-13	> 1.26E+01
10*	9.10E+01	< 2.37E-03	< 2.77E-12	< 2.96E-13	< 2.53E-04	< 3.18E-03	< 9.35E-14	> 1.30E+01
11*	1.70E+02	< 5.27E-03	< 3.50E-12	< 3.74E-13	< 5.63E-04	< 3.75E-03	< 2.87E-13	> 1.25E+01
12*	2.01E+02	< 3.71E-03	< 6.35E-12	< 6.79E-13	< 3.97E-04	< 4.14E-03	< 1.37E-12	> 1.19E+01
Mean:								< 1.65E-11 > 1.18E+01
Standard Deviation:								1.19E-11 3.83E-01

Co-60

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	1.15E-04	7.11E-11	1.57E-13	2.52E-07	2.52E-07	8.35E-18	1.71E+01
2*	3.06E-01	3.77E-03	8.98E-10	1.98E-12	8.30E-06	8.56E-06	1.12E-14	1.40E+01
3*	1.02E+00	3.98E-04	2.93E-11	6.45E-14	8.76E-07	9.43E-06	4.08E-17	1.64E+01
4*	2.02E+00	3.45E-04	1.81E-11	3.99E-14	7.60E-07	1.02E-05	3.79E-17	1.64E+01
5*	3.02E+00	2.52E-04	1.32E-11	2.91E-14	5.55E-07	1.07E-05	3.41E-17	1.65E+01
6*	4.03E+00	2.16E-04	1.13E-11	2.50E-14	4.76E-07	1.12E-05	3.51E-17	1.65E+01
7*	5.04E+00	2.04E-04	1.05E-11	2.32E-14	4.49E-07	1.17E-05	3.92E-17	1.64E+01
8*	1.81E+01	8.33E-04	3.35E-12	7.38E-15	1.83E-06	1.35E-05	9.24E-18	1.70E+01
9*	4.60E+01	1.06E-03	2.01E-12	4.42E-15	2.34E-06	1.58E-05	9.55E-18	1.70E+01
10*	9.10E+01	1.19E-03	1.39E-12	3.07E-15	2.63E-06	1.85E-05	1.01E-17	1.70E+01
11*	1.70E+02	1.03E-03	6.83E-13	1.50E-15	2.26E-06	2.07E-05	4.63E-18	1.73E+01
12*	2.01E+02	5.64E-04	9.64E-13	2.12E-15	1.24E-06	2.20E-05	1.34E-17	1.69E+01
Mean:								9.52E-16 1.65E+01
Standard Deviation:								9.30E-16 2.53E-01

TABLE G-5. Radionuclide and stable metal leaching data for Brunswick-1 cation resin waste-form specimen leached in synthetic seawater with pH 6.4. (continued)

Zn-65

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	< 1.23E-04	< 7.64E-11	< 1.27E-11	< 2.04E-05	< 2.04E-05	< 5.49E-14	> 1.33E+01
2*	3.06E-01	< 2.10E-04	< 5.01E-11	< 8.32E-12	< 3.50E-05	< 5.54E-05	< 1.98E-13	> 1.27E+01
3*	1.02E+00	< 1.69E-04	< 1.25E-11	< 2.07E-12	< 2.81E-05	< 8.36E-05	< 4.21E-14	> 1.34E+01
4*	2.02E+00	< 1.35E-04	< 7.07E-12	< 1.17E-12	< 2.24E-05	< 1.06E-04	< 3.28E-14	> 1.35E+01
5*	3.02E+00	< 1.28E-04	< 6.70E-12	< 1.11E-12	< 2.12E-05	< 1.27E-04	< 4.98E-14	> 1.33E+01
6*	4.03E+00	< 5.36E-04	< 2.81E-11	< 4.67E-12	< 8.90E-05	< 2.16E-04	< 1.23E-12	> 1.19E+01
7*	5.04E+00	< 1.62E-04	< 8.35E-12	< 1.39E-12	< 2.68E-05	< 2.43E-04	< 1.40E-13	> 1.29E+01
8*	1.81E+01	< 1.95E-04	< 7.86E-13	< 1.31E-13	< 3.25E-05	< 2.75E-04	< 2.90E-15	> 1.45E+01
9*	4.60E+01	< 1.92E-04	< 3.62E-13	< 6.02E-14	< 3.19E-05	< 3.07E-04	< 1.77E-15	> 1.48E+01
10*	9.10E+01	< 1.64E-04	< 1.91E-13	< 3.18E-14	< 2.72E-05	< 3.35E-04	< 1.08E-15	> 1.50E+01
11*	1.70E+02	< 1.88E-04	< 1.25E-13	< 2.08E-14	< 3.13E-05	< 3.66E-04	< 8.85E-16	> 1.51E+01
12*	2.01E+02	< 2.29E-04	< 3.91E-13	< 6.51E-14	< 3.80E-05	< 4.04E-04	< 1.26E-14	> 1.39E+01
Mean:								< 1.47E-13 > 1.37E+01
Standard Deviation:								9.98E-14 2.85E-01

Sb-125

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	< 9.26E-05	< 5.75E-11	< 2.62E-10	< 4.22E-04	< 4.22E-04	< 2.34E-11	> 1.06E+01
2*	3.06E-01	< 1.20E-04	< 2.84E-11	< 1.30E-10	< 5.45E-04	< 9.67E-04	< 4.81E-11	> 1.03E+01
3*	1.02E+00	< 1.27E-04	< 9.34E-12	< 4.26E-11	< 5.78E-04	< 1.54E-03	< 1.78E-11	> 1.08E+01
4*	2.02E+00	< 1.38E-04	< 7.26E-12	< 3.31E-11	< 6.30E-04	< 2.17E-03	< 2.60E-11	> 1.06E+01
5*	3.02E+00	< 1.29E-04	< 6.79E-12	< 3.09E-11	< 5.89E-04	< 2.76E-03	< 3.84E-11	> 1.04E+01
6*	4.03E+00	< 1.35E-04	< 7.10E-12	< 3.24E-11	< 6.17E-04	< 3.38E-03	< 5.90E-11	> 1.02E+01
7*	5.04E+00	< 9.21E-05	< 4.76E-12	< 2.17E-11	< 4.20E-04	< 3.80E-03	< 3.42E-11	> 1.05E+01
8*	1.81E+01	1.20E-04	4.81E-13	2.19E-12	5.46E-04	< 4.35E-03	8.18E-13	1.21E+01
9*	4.60E+01	< 1.59E-04	< 3.00E-13	< 1.37E-12	< 7.26E-04	< 5.07E-03	< 9.17E-13	> 1.20E+01
10*	9.10E+01	< 1.48E-04	< 1.72E-13	< 7.86E-13	< 6.73E-04	< 5.74E-03	< 6.61E-13	> 1.22E+01
11*	1.70E+02	< 1.01E-04	< 6.70E-14	< 3.05E-13	< 4.59E-04	< 6.20E-03	< 1.91E-13	> 1.27E+01
12*	2.01E+02	9.51E-05	1.63E-13	7.42E-13	4.34E-04	< 6.64E-03	1.64E-12	1.18E+01
Mean:								< 2.09E-11 > 1.12E+01
Standard Deviation:								5.98E-12 2.59E-01

Cs-134

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	8.26E-05	5.13E-11	9.35E-10	1.51E-03	1.51E-03	2.97E-10	9.53E+00
2*	3.06E-01	3.35E-04	7.98E-11	1.45E-09	6.11E-03	7.61E-03	6.05E-09	8.22E+00
3*	1.02E+00	2.86E-04	2.11E-11	3.84E-10	5.22E-03	1.28E-02	1.45E-09	8.84E+00
4*	2.02E+00	1.82E-04	9.58E-12	1.74E-10	3.32E-03	1.61E-02	7.23E-10	9.14E+00
5*	3.02E+00	7.99E-05	4.20E-12	7.65E-11	1.46E-03	1.76E-02	2.35E-10	9.63E+00
6*	4.03E+00	1.02E-04	5.34E-12	9.72E-11	1.85E-03	1.95E-02	5.32E-10	9.27E+00
7*	5.04E+00	< 4.60E-05	< 2.38E-12	< 4.33E-11	< 8.38E-04	< 2.03E-02	< 1.36E-10	> 9.87E+00
8*	1.81E+01	1.97E-04	7.93E-13	1.44E-11	3.59E-03	< 2.39E-02	3.55E-11	1.05E+01
9*	4.60E+01	1.82E-04	3.44E-13	6.26E-12	3.32E-03	< 2.72E-02	1.92E-11	1.07E+01
10*	9.10E+01	7.20E-05	8.41E-14	1.53E-12	1.31E-03	< 2.85E-02	2.51E-12	1.16E+01
11*	1.70E+02	7.83E-05	5.20E-14	9.48E-13	1.43E-03	< 2.99E-02	1.84E-12	1.17E+01
12*	2.01E+02	< 4.06E-05	< 6.94E-14	< 1.26E-12	< 7.39E-04	< 3.07E-02	< 4.76E-12	> 1.13E+01
Mean:								7.90E-10 1.00E+01
Standard Deviation:								4.94E-10 3.28E-01

TABLE G-5. Radionuclide and stable metal leaching data for Brunswick-1 cation resin waste-form specimen leached in synthetic seawater with pH 6.4. (continued)

Cs-137

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	1.44E-03	8.93E-10	3.72E-10	6.00E-04	6.00E-04	4.72E-11	1.03E+01
2*	3.06E-01	5.82E-03	1.38E-09	5.77E-10	2.43E-03	3.03E-03	9.54E-10	9.02E+00
3*	1.02E+00	5.35E-03	3.94E-10	1.64E-10	2.23E-03	5.26E-03	2.65E-10	9.58E+00
4*	2.02E+00	4.98E-03	2.62E-10	1.09E-10	2.08E-03	7.33E-03	2.82E-10	9.55E+00
5*	3.02E+00	2.47E-03	1.30E-10	5.40E-11	1.03E-03	8.36E-03	1.17E-10	9.93E+00
6*	4.03E+00	1.65E-03	8.67E-11	3.61E-11	6.89E-04	9.05E-03	7.36E-11	1.01E+01
7*	5.04E+00	1.20E-03	6.20E-11	2.59E-11	5.00E-04	9.55E-03	4.86E-11	1.03E+01
8*	1.81E+01	5.95E-03	2.39E-11	9.98E-12	2.48E-03	1.20E-02	1.69E-11	1.08E+01
9*	4.60E+01	5.28E-03	9.97E-12	4.16E-12	2.20E-03	1.42E-02	8.46E-12	1.11E+01
10*	9.10E+01	2.41E-03	2.82E-12	1.17E-12	1.01E-03	1.52E-02	1.48E-12	1.18E+01
11*	1.70E+02	8.79E-04	5.84E-13	2.44E-13	3.67E-04	1.56E-02	1.22E-13	1.29E+01
12*	2.01E+02	2.30E-04	3.94E-13	1.64E-13	9.60E-05	1.57E-02	8.02E-14	1.31E+01
Mean:			2.71E-10	1.13E-10			1.51E-10	1.07E+01
Standard Deviation:			1.26E-10	5.24E-11			7.83E-11	3.76E-01

Pu-241

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	NA	NA	NA	NA	NA	NA	NA
2*	3.06E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.02E+00	2.83E-05	2.08E-12	5.92E-12	8.04E-05	NA	3.44E-13	1.25E+01
4*	2.02E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.02E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.03E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.04E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.60E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
Mean:			NA	NA			NA	NA
Standard Deviation:			NA	NA			NA	NA

Fe

SAMPLE NUMBER	TOTAL TIME (days)	QUANTITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	< 8.25E+02	< 5.12E-04	< 4.66E-10	< 7.51E-04	< 7.51E-04	< 7.40E-11	> 1.01E+01
2*	3.06E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.02E+00	< 8.21E+02	< 6.05E-05	< 5.51E-11	< 7.47E-04	NA	< 2.97E-11	> 1.05E+01
4*	2.02E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.02E+00	< 8.25E+02	< 4.34E-05	< 3.95E-11	< 7.51E-04	NA	< 6.24E-11	> 1.02E+01
6*	4.03E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.04E+00	< 8.03E+02	< 4.15E-05	< 3.78E-11	< 7.30E-04	NA	< 1.04E-10	> 9.98E+00
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.60E+01	< 8.14E+02	< 1.53E-06	< 1.40E-12	< 7.41E-04	NA	< 9.55E-13	> 1.20E+01
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
(90 days) Mean:			< 1.32E-04	< 1.20E-10			< 5.41E-11	> 1.06E+01
Standard Deviation:			9.56E-05	8.70E-11			1.78E-11	3.72E-01

TABLE G-5. Radionuclide and stable metal leaching data for Brunswick-1 cation resin waste-form specimen leached in synthetic seawater with pH 6.4. (continued)

Ni

SAMPLE NUMBER	TOTAL TIME (days)	QUANTITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	< 4.40E+02	< 2.73E-04	< 2.21E-09	< 3.56E-03	< 3.56E-03	< 1.66E-09	> 8.78E+00
2*	3.06E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.02E+00	< 4.38E+02	< 3.23E-05	< 2.61E-10	< 3.54E-03	NA	< 6.67E-10	> 9.18E+00
4*	2.02E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.02E+00	< 4.40E+02	< 2.31E-05	< 1.87E-10	< 3.56E-03	NA	< 1.40E-09	> 8.85E+00
6*	4.03E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.04E+00	< 4.28E+02	< 2.21E-05	< 1.79E-10	< 3.46E-03	NA	< 2.32E-09	> 8.63E+00
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.60E+01	< 4.34E+02	< 8.19E-07	< 6.61E-12	< 3.51E-03	NA	< 2.14E-11	> 1.07E+01
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
(90 days)		Mean:	< 7.03E-05	< 5.68E-10			< 1.21E-09	> 9.22E+00
Standard Deviation:			5.10E-05	4.12E-10			3.99E-10	3.72E-01

Co

SAMPLE NUMBER	TOTAL TIME (days)	QUANTITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	< 5.50E+02	< 3.42E-04	< 9.58E-09	< 1.54E-02	< 1.54E-02	< 3.12E-08	> 7.51E+00
2*	3.06E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.02E+00	< 5.48E+02	< 4.03E-05	< 1.13E-09	< 1.54E-02	NA	< 1.26E-08	> 7.90E+00
4*	2.02E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.02E+00	< 5.50E+02	< 2.89E-05	< 8.11E-10	< 1.54E-02	NA	< 2.64E-08	> 7.58E+00
6*	4.03E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.04E+00	< 5.35E+02	< 2.77E-05	< 7.76E-10	< 1.50E-02	NA	< 4.37E-08	> 7.36E+00
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.60E+01	< 5.43E+02	< 1.02E-06	< 2.87E-11	< 1.52E-02	NA	< 4.03E-10	> 9.39E+00
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
(90 days)		Mean:	< 8.79E-05	< 2.47E-09			< 2.29E-08	> 7.95E+00
Standard Deviation:			6.37E-05	1.79E-09			7.51E-09	3.72E-01

Cr

SAMPLE NUMBER	TOTAL TIME (days)	QUANTITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	1.87E+02	1.16E-04	1.51E-09	2.43E-03	2.43E-03	7.75E-10	9.11E+00
2*	3.06E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.02E+00	6.70E+02	4.94E-05	6.41E-10	8.71E-03	NA	4.04E-09	8.39E+00
4*	2.02E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.02E+00	2.55E+02	1.34E-05	1.74E-10	3.32E-03	NA	1.22E-09	8.91E+00
6*	4.03E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.04E+00	8.13E+01	4.21E-06	5.46E-11	1.06E-03	NA	2.17E-10	9.66E+00
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.60E+01	1.19E+03	2.25E-06	2.92E-11	1.55E-02	NA	4.17E-10	9.38E+00
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
(90 days)		Mean:	3.71E-05	4.82E-10			1.33E-09	9.09E+00
Standard Deviation:			2.15E-05	2.79E-10			6.97E-10	2.16E-01

TABLE G-6. Radionuclide and stable metal leaching data for Brunswick-1 mixed-bed resin waste-form specimen leached in deionized water.

Mn-54

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.96E-02	9.30E-04	3.67E-10	1.21E-10	3.06E-04	3.06E-04	3.53E-12	1.15E+01
2*	2.99E-01	2.07E-03	3.50E-10	1.15E-10	6.81E-04	9.87E-04	2.55E-11	1.06E+01
3*	1.01E+00	< 9.71E-05	< 6.53E-12	< 2.15E-12	< 3.19E-05	< 1.02E-03	< 2.99E-14	> 1.35E+01
4*	2.01E+00	1.18E-03	5.62E-11	1.85E-11	3.88E-04	< 1.41E-03	5.39E-12	1.13E+01
5*	3.01E+00	< 9.07E-05	< 5.90E-12	< 1.94E-12	< 2.98E-05	< 1.44E-03	< 1.01E-13	> 1.30E+01
6*	4.01E+00	< 6.45E-05	< 4.18E-12	< 1.38E-12	< 2.12E-05	< 1.46E-03	< 7.12E-14	> 1.31E+01
7*	5.03E+00	< 1.21E-04	< 7.89E-12	< 2.60E-12	< 4.00E-05	< 1.50E-03	< 3.27E-13	> 1.25E+01
8*	1.81E+01	4.68E-04	2.39E-12	7.87E-13	1.54E-04	< 1.65E-03	7.04E-14	1.32E+01
9*	4.60E+01	< 9.15E-05	< 2.20E-13	< 7.22E-14	< 3.01E-05	< 1.68E-03	< 1.71E-15	> 1.48E+01
10*	9.10E+01	< 1.25E-04	< 1.86E-13	< 6.13E-14	< 4.12E-05	< 1.72E-03	< 2.69E-15	> 1.46E+01
11*	1.70E+02	2.08E-04	1.79E-13	5.88E-14	6.83E-05	< 1.79E-03	4.75E-15	1.43E+01
12*	2.01E+02	< 9.02E-05	< 2.00E-13	< 6.58E-14	< 2.97E-05	< 1.82E-03	< 8.65E-15	> 1.41E+01
13*	2.32E+02	< 8.32E-05	< 1.82E-13	< 5.99E-14	< 2.74E-05	< 1.85E-03	< 8.37E-15	> 1.41E+01
14*	2.84E+02	< 9.98E-05	< 1.31E-13	< 4.32E-14	< 3.28E-05	< 1.88E-03	< 5.17E-15	> 1.43E+01
15*	3.12E+02	< 9.52E-05	< 2.32E-13	< 7.62E-14	< 3.13E-05	< 1.91E-03	< 1.86E-14	> 1.37E+01
16*	3.88E+02	2.65E-04	2.38E-13	7.83E-14	8.73E-05	< 2.00E-03	2.30E-14	1.36E+01
=====								
		Mean:	< 5.34E-11	< 1.76E-11			< 2.34E-12	> 1.32E+01
	Standard Deviation:		3.22E-11	1.06E-11			1.71E-12	3.29E-01

Fe-55

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.96E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.99E-01	1.34E-02	2.26E-09	1.12E-10	6.65E-04	NA	2.43E-11	1.06E+01
3*	1.01E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.01E+00	5.29E-02	2.52E-09	1.25E-10	2.63E-03	NA	2.47E-10	9.61E+00
5*	3.01E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.01E+00	2.21E-02	1.43E-09	7.13E-11	1.10E-03	NA	1.91E-10	9.72E+00
7*	5.03E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.81E+01	9.80E-03	5.01E-11	2.49E-12	4.87E-04	NA	7.06E-13	1.22E+01
9*	4.60E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.10E+01	5.53E-03	8.22E-12	4.09E-13	2.75E-04	NA	1.20E-13	1.29E+01
11*	1.70E+02	NA	NA	NA	NA	NA	NA	NA
12*	2.01E+02	NA	NA	NA	NA	NA	NA	NA
13*	2.32E+02	NA	NA	NA	NA	NA	NA	NA
14*	2.84E+02	NA	NA	NA	NA	NA	NA	NA
15*	3.12E+02	NA	NA	NA	NA	NA	NA	NA
16*	3.88E+02	NA	NA	NA	NA	NA	NA	NA
(90 Days)		Mean:	1.25E-09	6.23E-11			9.27E-11	1.10E+01
Standard Deviation:			5.31E-10	2.64E-11			5.26E-11	6.61E-01

TABLE G-6. Radionuclide and stable metal leaching data for Brunswick-1 mixed-bed resin waste-form specimen leached in deionized water. (continued)

Co-58

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.96E-02	< 3.15E-03	< 1.24E-09	< 3.10E-09	< 7.85E-03	< 7.85E-03	< 2.32E-09	> 8.63E+00
2*	2.99E-01	< 6.46E-03	< 1.09E-09	< 2.72E-09	< 1.61E-02	< 2.40E-02	< 1.43E-08	> 7.85E+00
3*	1.01E+00	< 4.73E-03	< 3.18E-10	< 7.92E-10	< 1.18E-02	< 3.57E-02	< 4.07E-09	> 8.39E+00
4*	2.01E+00	4.03E-03	1.92E-10	4.78E-10	1.00E-02	< 4.58E-02	3.60E-09	8.44E+00
5*	3.01E+00	< 3.69E-03	< 2.40E-10	< 5.97E-10	< 9.18E-03	< 5.50E-02	< 9.53E-09	> 8.02E+00
6*	4.01E+00	< 2.41E-03	< 1.56E-10	< 3.90E-10	< 6.01E-03	< 6.10E-02	< 5.71E-09	> 8.24E+00
7*	5.03E+00	< 4.92E-03	< 1.57E-10	< 3.92E-10	< 6.04E-03	< 6.70E-02	< 7.46E-09	> 8.13E+00
8*	1.81E+01	< 3.61E-03	< 1.85E-11	< 4.61E-11	< 9.01E-03	< 7.60E-02	< 2.41E-10	> 9.62E+00
9*	4.60E+01	< 4.13E-03	< 9.90E-12	< 2.47E-11	< 1.03E-02	< 8.63E-02	< 2.00E-10	> 9.70E+00
10*	9.10E+01	< 5.18E-03	< 7.70E-12	< 1.92E-11	< 1.29E-02	< 9.92E-02	< 2.64E-10	> 9.58E+00
11*	1.70E+02	< 4.92E-03	< 4.23E-12	< 1.06E-11	< 1.23E-02	< 1.11E-01	< 1.53E-10	> 9.82E+00
12*	2.01E+02	< 5.13E-03	< 1.14E-11	< 2.83E-11	< 1.28E-02	< 1.24E-01	< 1.60E-09	> 8.79E+00
13*	2.32E+02	< 3.95E-03	< 8.65E-12	< 2.15E-11	< 9.84E-03	< 1.34E-01	< 1.08E-09	> 8.97E+00
14*	2.84E+02	< 4.57E-03	< 6.00E-12	< 1.50E-11	< 1.14E-02	< 1.45E-01	< 6.20E-10	> 9.21E+00
15*	3.12E+02	< 6.96E-03	< 1.69E-11	< 4.22E-11	< 1.73E-02	< 1.63E-01	< 5.71E-09	> 8.24E+00
16*	3.88E+02	NA	NA	NA	NA	NA	NA	NA
=====								
		Mean:	< 2.32E-10	< 5.79E-10				
		Standard Deviation:	1.02E-10	2.54E-10				
							< 3.79E-09	> 8.78E+00
							1.07E-09	1.72E-01

Co-60

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.96E-02	4.20E-03	1.66E-09	8.87E-11	2.24E-04	2.24E-04	1.90E-12	1.17E+01
2*	2.99E-01	1.04E-02	1.76E-09	9.38E-11	5.55E-04	7.80E-04	1.70E-11	1.08E+01
3*	1.01E+00	6.44E-04	4.33E-11	2.31E-12	3.44E-05	8.14E-04	3.46E-14	1.35E+01
4*	2.01E+00	5.31E-03	2.53E-10	1.35E-11	2.84E-04	1.10E-03	2.88E-12	1.15E+01
5*	3.01E+00	4.14E-04	2.69E-11	1.44E-12	2.21E-05	1.12E-03	5.51E-14	1.33E+01
6*	4.01E+00	1.10E-04	7.12E-12	3.80E-13	5.86E-06	1.13E-03	5.43E-15	1.43E+01
7*	5.03E+00	1.57E-04	1.02E-11	5.43E-13	8.36E-06	1.13E-03	1.43E-14	1.38E+01
8*	1.81E+01	2.79E-03	1.43E-11	7.63E-13	1.49E-04	1.28E-03	6.62E-14	1.32E+01
9*	4.60E+01	4.24E-04	1.02E-12	5.43E-14	2.26E-05	1.31E-03	9.68E-16	1.50E+01
10*	9.10E+01	4.28E-04	6.36E-13	3.40E-14	2.29E-05	1.33E-03	8.28E-16	1.51E+01
11*	1.70E+02	1.58E-03	1.36E-12	7.24E-14	8.42E-05	1.41E-03	7.21E-15	1.41E+01
12*	2.01E+02	3.46E-04	7.67E-13	4.10E-14	1.85E-05	1.43E-03	3.35E-15	1.45E+01
13*	2.32E+02	6.77E-04	1.48E-12	7.91E-14	3.61E-05	1.47E-03	1.46E-14	1.38E+01
14*	2.84E+02	7.58E-04	9.97E-13	5.32E-14	4.05E-05	1.51E-03	7.85E-15	1.41E+01
15*	3.12E+02	9.02E-04	2.20E-12	1.17E-13	4.81E-05	1.56E-03	4.40E-14	1.34E+01
16*	3.88E+02	1.91E-03	1.71E-12	9.12E-14	1.02E-04	1.66E-03	3.13E-14	1.35E+01
=====								
		Mean:	2.36E-10	1.26E-11				
		Standard Deviation:	1.45E-10	7.72E-12				
							1.38E-12	1.35E+01
							1.06E-12	3.03E-01

TABLE G-6. Radionuclide and stable metal leaching data for Brunswick-1 mixed-bed resin waste-form specimen leached in deionized water. (continued)

Ni-63

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.96E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.99E-01	1.55E-03	2.62E-10	4.44E-11	2.63E-04	NA	3.81E-12	1.14E+01
3*	1.01E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.01E+00	1.66E-03	7.88E-11	1.34E-11	2.81E-04	NA	2.82E-12	1.16E+01
5*	3.01E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.01E+00	7.11E-04	4.61E-11	7.81E-12	1.21E-04	NA	2.30E-12	1.16E+01
7*	5.03E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.81E+01	6.78E-03	3.47E-11	5.88E-12	1.15E-03	NA	3.94E-12	1.14E+01
9*	4.60E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.10E+01	9.12E-05	1.36E-13	2.30E-14	1.55E-05	NA	3.79E-16	1.54E+01
11*	1.70E+02	NA	NA	NA	NA	NA	NA	NA
12*	2.01E+02	NA	NA	NA	NA	NA	NA	NA
13*	2.32E+02	NA	NA	NA	NA	NA	NA	NA
14*	2.84E+02	NA	NA	NA	NA	NA	NA	NA
15*	3.12E+02	NA	NA	NA	NA	NA	NA	NA
16*	3.88E+02	NA	NA	NA	NA	NA	NA	NA
=====								
(90 Days)		Mean:	8.44E-11	1.43E-11			2.57E-12	1.23E+01
Standard Deviation:			4.62E-11	7.83E-12			7.12E-13	7.85E-01

Zn-65

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.96E-02	< 3.38E-04	< 1.34E-10	< 4.92E-10	< 1.24E-03	< 1.24E-03	< 5.83E-11	> 1.02E+01
2*	2.99E-01	< 4.63E-04	< 7.82E-11	< 2.88E-10	< 1.70E-03	< 2.95E-03	< 1.59E-10	> 9.80E+00
3*	1.01E+00	< 1.62E-04	< 1.09E-11	< 4.01E-11	< 5.97E-04	< 3.54E-03	< 1.04E-11	> 1.10E+01
4*	2.01E+00	< 3.35E-04	< 1.60E-11	< 5.87E-11	< 1.23E-03	< 4.78E-03	< 5.44E-11	> 1.03E+01
5*	3.01E+00	< 1.96E-04	< 1.28E-11	< 4.69E-11	< 7.21E-04	< 5.50E-03	< 5.88E-11	> 1.02E+01
6*	4.01E+00	< 1.54E-04	< 9.95E-12	< 3.66E-11	< 5.65E-04	< 6.06E-03	< 5.03E-11	> 1.03E+01
7*	5.03E+00	< 1.82E-04	< 1.18E-11	< 4.34E-11	< 6.69E-04	< 6.73E-03	< 9.15E-11	> 1.00E+01
8*	1.81E+01	< 2.58E-04	< 1.32E-12	< 4.85E-12	< 9.47E-04	< 7.68E-03	< 2.67E-12	> 1.16E+01
9*	4.60E+01	< 4.42E-04	< 1.06E-12	< 3.90E-12	< 1.63E-03	< 9.30E-03	< 4.99E-12	> 1.13E+01
10*	9.10E+01	< 2.36E-04	< 3.51E-13	< 1.29E-12	< 8.69E-04	< 1.02E-02	< 1.20E-12	> 1.19E+01
11*	1.70E+02	< 4.23E-04	< 3.64E-13	< 1.34E-12	< 1.56E-03	< 1.17E-02	< 2.46E-12	> 1.16E+01
12*	2.01E+02	< 2.10E-04	< 4.65E-13	< 1.71E-12	< 7.71E-04	< 1.25E-02	< 5.83E-12	> 1.12E+01
13*	2.32E+02	< 2.85E-04	< 6.24E-13	< 2.29E-12	< 1.05E-03	< 1.35E-02	< 1.22E-11	> 1.09E+01
14*	2.84E+02	2.53E-04	3.32E-13	1.22E-12	9.29E-04	< 1.45E-02	4.14E-12	> 1.14E+01
15*	3.12E+02	< 1.83E-04	< 4.46E-13	< 1.64E-12	< 6.73E-04	< 1.51E-02	< 8.61E-12	> 1.11E+01
16*	3.88E+02	< 4.63E-04	< 4.15E-13	< 1.53E-12	< 1.70E-03	< 1.68E-02	< 8.76E-12	> 1.11E+01
=====								
		Mean:	< 1.86E-11	< 6.82E-11			< 3.50E-11	> 1.09E+01
Standard Deviation:			9.67E-12	3.55E-11			1.16E-11	1.71E-01

TABLE G-6. Radionuclide and stable metal leaching data for Brunswick-1 mixed-bed resin waste-form specimen leached in deionized water. (continued)

Sr-90

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.96E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.99E-01	1.13E-03	1.91E-10	1.70E-09	1.01E-02	NA	5.58E-09	8.25E+00
3*	1.01E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.01E+00	7.56E-03	3.60E-10	3.21E-09	6.74E-02	NA	1.63E-07	6.79E+00
5*	3.01E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.01E+00	3.97E-03	2.57E-10	2.29E-09	3.54E-02	NA	1.97E-07	6.70E+00
7*	5.03E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.81E+01	1.34E-04	6.86E-13	6.12E-12	1.20E-03	NA	4.25E-12	1.14E+01
9*	4.60E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.10E+01	9.66E-05	1.44E-13	1.28E-12	8.62E-04	NA	1.18E-12	1.19E+01
11*	1.70E+02	NA	NA	NA	NA	NA	NA	NA
12*	2.01E+02	NA	NA	NA	NA	NA	NA	NA
13*	2.32E+02	NA	NA	NA	NA	NA	NA	NA
14*	2.84E+02	NA	NA	NA	NA	NA	NA	NA
15*	3.12E+02	NA	NA	NA	NA	NA	NA	NA
16*	3.88E+02	NA	NA	NA	NA	NA	NA	NA
=====								
(90 Days)		Mean:	1.62E-10	1.44E-09			7.32E-08	9.01E+00
Standard Deviation:			7.12E-11	6.35E-10			4.40E-08	1.12E+00

Sb-125

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.96E-02	5.21E-04	2.06E-10	2.86E-10	7.24E-04	7.24E-04	1.97E-11	1.07E+01
2*	2.99E-01	5.71E-04	9.65E-11	1.34E-10	7.93E-04	1.52E-03	3.46E-11	1.05E+01
3*	1.01E+00	6.28E-04	4.22E-11	5.86E-11	8.72E-04	2.39E-03	2.22E-11	1.07E+01
4*	2.01E+00	4.46E-04	2.12E-11	2.95E-11	6.19E-04	3.01E-03	1.37E-11	1.09E+01
5*	3.01E+00	3.00E-04	1.95E-11	2.71E-11	4.17E-04	3.42E-03	1.96E-11	1.07E+01
6*	4.01E+00	3.91E-04	2.54E-11	3.52E-11	5.43E-04	3.97E-03	4.66E-11	1.03E+01
7*	5.03E+00	3.10E-04	2.02E-11	2.80E-11	4.31E-04	4.40E-03	3.80E-11	1.04E+01
8*	1.81E+01	2.37E-04	1.21E-12	1.69E-12	3.29E-04	4.73E-03	3.23E-13	1.25E+01
9*	4.60E+01	1.67E-04	4.00E-13	5.55E-13	2.31E-04	4.96E-03	1.01E-13	1.30E+01
10*	9.10E+01	4.50E-04	6.69E-13	9.28E-13	6.25E-04	5.58E-03	6.18E-13	1.22E+01
11*	1.70E+02	1.78E-04	1.53E-13	2.13E-13	2.47E-04	5.83E-03	6.21E-14	1.32E+01
12*	2.01E+02	< 2.27E-04	< 5.03E-13	< 6.99E-13	< 3.15E-04	< 6.15E-03	< 9.74E-13	> 1.20E+01
13*	2.32E+02	3.10E-04	6.78E-13	9.42E-13	4.30E-04	< 6.58E-03	2.07E-12	1.17E+01
14*	2.84E+02	5.01E-04	6.59E-13	9.15E-13	6.95E-04	< 7.27E-03	2.32E-12	1.16E+01
15*	3.12E+02	7.22E-04	1.76E-12	2.44E-12	1.00E-03	< 8.27E-03	1.91E-11	1.07E+01
16*	3.88E+02	5.54E-04	4.97E-13	6.90E-13	7.69E-04	< 9.04E-03	1.79E-12	1.17E+01
=====								
Mean:			2.73E-11	3.80E-11			1.39E-11	1.14E+01
Standard Deviation:			1.35E-11	1.87E-11			3.86E-12	2.37E-01

TABLE G-6. Radionuclide and stable metal leaching data for Brunswick-1 mixed-bed resin waste-form specimen leached in deionized water. (continued)

Cs-134

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.96E-02	2.00E-04	7.89E-11	7.91E-09	2.00E-02	2.00E-02	1.51E-08	7.82E+00
2*	2.99E-01	1.99E-04	3.37E-11	3.37E-09	2.00E-02	4.00E-02	2.19E-08	7.66E+00
3*	1.01E+00	2.84E-04	1.91E-11	1.91E-09	2.84E-02	6.84E-02	2.37E-08	7.63E+00
4*	2.01E+00	1.12E-04	5.35E-12	5.36E-10	1.13E-02	7.97E-02	4.53E-09	8.34E+00
5*	3.01E+00	6.62E-05	4.31E-12	4.32E-10	6.64E-03	8.63E-02	4.98E-09	8.30E+00
6*	4.01E+00	< 3.68E-05	< 2.39E-12	< 2.39E-10	< 3.69E-03	< 9.00E-02	< 2.15E-09	> 8.67E+00
7*	5.03E+00	< 8.59E-05	< 5.58E-12	< 5.59E-10	< 8.61E-03	< 9.86E-02	< 1.52E-08	> 7.82E+00
8*	1.81E+01	8.18E-05	4.18E-13	4.19E-11	8.19E-03	< 1.07E-01	2.00E-10	9.70E+00
9*	4.60E+01	< 7.94E-05	< 1.90E-13	< 1.91E-11	< 7.95E-03	< 1.15E-01	< 1.19E-10	> 9.92E+00
10*	9.10E+01	< 6.31E-05	< 9.38E-14	< 9.40E-12	< 6.32E-03	< 1.21E-01	< 6.33E-11	> 1.02E+01
11*	1.70E+02	< 6.10E-05	< 5.24E-14	< 5.25E-12	< 6.11E-03	< 1.27E-01	< 3.79E-11	> 1.04E+01
12*	2.01E+02	< 5.03E-05	< 1.12E-13	< 1.12E-11	< 5.04E-03	< 1.32E-01	< 2.50E-10	> 9.60E+00
13*	2.32E+02	< 4.38E-05	< 9.59E-14	< 9.61E-12	< 4.39E-03	< 1.37E-01	< 2.15E-10	> 9.67E+00
14*	2.84E+02	< 4.22E-05	< 5.56E-14	< 5.57E-12	< 4.23E-03	< 1.41E-01	< 8.59E-11	> 1.01E+01
15*	3.12E+02	< 7.91E-05	< 1.93E-13	< 1.93E-11	< 7.93E-03	< 1.49E-01	< 1.19E-09	> 8.92E+00
16*	3.88E+02	< 9.31E-05	< 8.36E-14	< 8.38E-12	< 9.33E-03	< 1.58E-01	< 2.64E-10	> 9.58E+00
Mean:								< 5.62E-09 > 9.02E+00
Standard Deviation:								2.09E-09 2.46E-01

Cs-137

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.96E-02	2.23E-03	8.83E-10	1.70E-08	4.29E-02	4.29E-02	6.94E-08	7.16E+00
2*	2.99E-01	2.20E-03	3.72E-10	7.14E-09	4.23E-02	8.52E-02	9.84E-08	7.01E+00
3*	1.01E+00	2.96E-03	1.99E-10	3.82E-09	5.68E-02	1.42E-01	9.44E-08	7.02E+00
4*	2.01E+00	9.20E-04	4.38E-11	8.42E-10	1.77E-02	1.60E-01	1.12E-08	7.95E+00
5*	3.01E+00	7.32E-04	4.76E-11	9.15E-10	1.41E-02	1.74E-01	2.24E-08	7.65E+00
6*	4.01E+00	3.65E-04	2.37E-11	4.55E-10	7.02E-03	1.81E-01	7.78E-09	8.11E+00
7*	5.03E+00	3.37E-04	2.19E-11	4.20E-10	6.47E-03	1.87E-01	8.57E-09	8.07E+00
8*	1.81E+01	5.70E-04	2.91E-12	5.60E-11	1.09E-02	1.98E-01	3.56E-10	9.45E+00
9*	4.60E+01	5.41E-04	1.30E-12	2.49E-11	1.04E-02	2.09E-01	1.27E-08	7.90E+00
10*	9.10E+01	3.09E-04	4.59E-13	8.83E-12	5.94E-03	2.15E-01	6.83E-09	8.17E+00
11*	1.70E+02	1.77E-04	1.53E-13	2.93E-12	3.41E-03	2.18E-01	3.76E-09	8.42E+00
12*	2.01E+02	< 9.60E-05	< 2.13E-13	< 4.09E-12	< 1.85E-03	< 2.20E-01	< 3.24E-09	> 8.49E+00
13*	2.32E+02	4.42E-05	9.67E-14	1.86E-12	8.49E-04	< 2.21E-01	2.84E-09	8.55E+00
14*	2.84E+02	7.70E-05	1.01E-13	1.94E-12	1.48E-03	< 2.22E-01	2.35E-09	8.63E+00
15*	3.12E+02	1.41E-04	3.43E-13	6.58E-12	2.71E-03	< 2.25E-01	2.20E-09	8.66E+00
16*	3.88E+02	7.80E-05	7.00E-14	1.35E-12	1.50E-03	< 2.26E-01	1.81E-09	8.74E+00
Mean:								2.18E-08 8.12E+00
Standard Deviation:								8.38E-09 1.68E-01

TABLE G-6. Radionuclide and stable metal leaching data for Brunswick-1 mixed-bed resin waste-form specimen leached in deionized water. (continued)

Pu-241

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.96E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.99E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.01E+00	2.68E-05	1.80E-12	6.34E-12	9.43E-05	NA	2.60E-13	1.26E+01
4*	2.01E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.01E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.01E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.03E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.60E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
Mean:			NA	NA			NA	NA
Standard Deviation:			NA	NA			NA	NA

Fe

SAMPLE NUMBER	TOTAL TIME (days)	QUANTITY LEACHED (ug)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.96E-02	< 1.60E+02	< 6.31E-05	< 6.61E-10	< 1.67E-03	< 1.67E-03	< 1.05E-10	> 9.98E+00
2*	2.99E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.01E+00	3.54E+01	2.38E-06	2.49E-11	3.70E-04	NA	4.01E-12	1.14E+01
4*	2.01E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.01E+00	7.68E+01	5.00E-06	5.23E-11	8.05E-04	NA	7.32E-11	1.01E+01
6*	4.01E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.03E+00	< 1.59E+02	< 1.03E-05	< 1.08E-10	< 1.67E-03	NA	< 5.67E-10	> 9.25E+00
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.60E+01	7.85E+01	1.88E-07	1.97E-12	8.22E-04	NA	1.27E-12	1.19E+01
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
(90 Days)		Mean:	< 1.62E-05	< 1.70E-10			< 1.50E-10	> 1.05E+01
		Standard Deviation:	1.19E-05	1.24E-10			1.06E-10	4.86E-01

Ni

SAMPLE NUMBER	TOTAL TIME (days)	QUANTITY LEACHED (ug)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.96E-02	< 8.52E+01	< 3.37E-05	< 3.77E-09	< 9.55E-03	< 9.55E-03	< 3.43E-09	> 8.46E+00
2*	2.99E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.01E+00	< 8.32E+01	< 5.59E-06	< 6.27E-10	< 9.32E-03	NA	< 2.54E-09	> 8.59E+00
4*	2.01E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.01E+00	< 7.88E+01	< 5.12E-06	< 5.74E-10	< 8.83E-03	NA	< 8.81E-09	> 8.05E+00
6*	4.01E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.03E+00	< 8.48E+01	< 5.51E-06	< 6.17E-10	< 9.50E-03	NA	< 1.85E-08	> 7.73E+00
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.60E+01	< 8.72E+01	< 2.09E-07	< 2.34E-11	< 9.77E-03	NA	< 1.80E-10	> 9.74E+00
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
(90 Days)		Mean:	< 1.00E-05	< 1.12E-09			< 6.69E-09	> 8.52E+00
		Standard Deviation:	6.00E-06	6.72E-10			3.27E-09	3.42E-01

TABLE G-6. Radionuclide and stable metal leaching data for Brunswick-1 mixed-bed resin waste-form specimen leached in deionized water. (continued)

Co

SAMPLE NUMBER	TOTAL TIME (days)	QUANTITY LEACHED (ug)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.96E-02	< 1.07E+02	< 4.21E-05	< 1.02E-09	< 2.58E-03	< 2.58E-03	< 2.51E-10	> 9.60E+00
2*	2.99E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.01E+00	< 1.04E+02	< 6.99E-06	< 1.70E-10	< 2.52E-03	NA	< 1.86E-10	> 9.73E+00
4*	2.01E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.01E+00	< 9.85E+01	< 6.40E-06	< 1.55E-10	< 2.39E-03	NA	< 6.46E-10	> 9.19E+00
6*	4.01E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.03E+00	< 1.06E+02	< 6.88E-06	< 1.67E-10	< 2.57E-03	NA	< 1.35E-09	> 8.87E+00
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.60E+01	< 1.09E+02	< 2.61E-07	< 6.34E-12	< 2.64E-03	NA	< 1.32E-11	> 1.09E+01
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
=====								
(90 Days)		Mean:	< 1.25E-05	< 3.04E-10			< 4.90E-10	> 9.65E+00
Standard Deviation:			7.50E-06	1.82E-10			2.39E-10	3.42E-01

Cr

SAMPLE NUMBER	TOTAL TIME (days)	QUANTITY LEACHED (ug)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.96E-02	2.98E+01	1.18E-05	5.37E-11	1.36E-04	1.36E-04	6.96E-13	1.22E+01
2*	2.99E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.01E+00	< 2.08E+01	< 1.40E-06	< 8.38E-12	< 9.49E-05	NA	< 2.63E-13	> 1.26E+01
4*	2.01E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.01E+00	4.53E+01	2.95E-06	1.34E-11	2.07E-04	NA	4.83E-12	1.13E+01
6*	4.01E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.03E+00	< 2.12E+01	< 1.38E-06	< 6.28E-12	< 9.67E-05	NA	< 1.91E-12	> 1.17E+01
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.60E+01	< 2.18E+01	< 5.23E-08	< 2.38E-13	< 9.94E-05	NA	< 1.87E-14	> 1.37E+01
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
=====								
(90 Days)		Mean:	< 3.51E-06	< 1.60E-11			< 1.54E-12	> 1.23E+01
Standard Deviation:			2.12E-06	9.66E-12			8.83E-13	4.15E-01

TABLE G-7. Radionuclide and stable metal leaching data for Brunswick-1 mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with pH 10.4.

Mn-54

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	< 6.12E-05	< 4.67E-11	< 1.77E-11	< 2.31E-05	< 2.31E-05	< 5.40E-14	> 1.33E+01
2*	2.93E-01	7.69E-05	1.36E-11	5.13E-12	2.91E-05	< 5.22E-05	3.72E-14	1.34E+01
3*	1.00E+00	< 1.17E-04	< 7.76E-12	< 2.93E-12	< 4.41E-05	< 9.63E-05	< 4.17E-14	> 1.34E+01
4*	2.00E+00	< 7.43E-05	< 3.50E-12	< 1.32E-12	< 2.81E-05	< 1.24E-04	< 2.08E-14	> 1.37E+01
5*	3.00E+00	< 1.14E-04	< 6.79E-12	< 2.57E-12	< 4.32E-05	< 1.68E-04	< 1.33E-13	> 1.29E+01
6*	4.00E+00	< 1.27E-04	< 8.11E-12	< 3.06E-12	< 4.79E-05	< 2.16E-04	< 2.67E-13	> 1.26E+01
7*	5.01E+00	< 1.00E-04	< 6.37E-12	< 2.40E-12	< 3.79E-05	< 2.53E-04	< 2.12E-13	> 1.27E+01
8*	1.81E+01	< 8.53E-05	< 4.17E-13	< 1.58E-13	< 3.22E-05	< 2.86E-04	< 2.14E-15	> 1.47E+01
9*	4.60E+01	< 6.77E-05	< 1.55E-13	< 5.87E-14	< 2.56E-05	< 3.11E-04	< 8.56E-16	> 1.51E+01
10*	9.11E+01	< 8.38E-05	< 1.19E-13	< 4.49E-14	< 3.17E-05	< 3.43E-04	< 1.10E-15	> 1.50E+01
11*	1.70E+02	< 7.80E-05	< 6.52E-14	< 2.46E-14	< 2.95E-05	< 3.72E-04	< 6.33E-16	> 1.52E+01
12*	2.01E+02	< 1.23E-04	< 2.73E-13	< 1.03E-13	< 4.63E-05	< 4.19E-04	< 1.62E-14	> 1.38E+01
=====								
		Mean:	< 7.82E-12	< 2.95E-12				
		Standard Deviation:	3.75E-12	1.42E-12				
							< 6.56E-14	> 1.38E+01
							2.60E-14	2.74E-01

Fe-55

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.93E-01	7.98E-04	1.41E-10	8.03E-12	4.55E-05	NA	9.13E-14	1.30E+01
3*	1.00E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.00E+00	2.12E-03	9.98E-11	5.69E-12	1.21E-04	NA	3.86E-13	1.24E+01
5*	3.00E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.00E+00	1.42E-03	9.06E-11	5.17E-12	8.09E-05	NA	7.61E-13	1.21E+01
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.81E+01	8.73E-04	4.27E-12	2.43E-13	4.98E-05	NA	5.10E-15	1.43E+01
9*	4.60E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.11E+01	5.53E-04	7.84E-13	4.47E-14	3.16E-05	NA	1.09E-15	1.50E+01
11*	1.70E+02	NA	NA	NA	NA	NA	NA	NA
12*	2.01E+02	NA	NA	NA	NA	NA	NA	NA
=====								
(90 Days)		Mean:	6.72E-11	3.84E-12				
		Standard Deviation:	2.77E-11	1.58E-12				
							2.49E-13	1.34E+01
							1.46E-13	5.47E-01

Co-58

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	< 2.03E-03	< 1.55E-09	< 4.44E-09	< 5.82E-03	< 5.82E-03	< 3.41E-09	> 8.47E+00
2*	2.93E-01	< 2.86E-03	< 5.05E-10	< 1.45E-09	< 8.19E-03	< 1.40E-02	< 2.96E-09	> 8.53E+00
3*	1.00E+00	< 3.52E-03	< 2.34E-10	< 6.69E-10	< 1.01E-02	< 2.41E-02	< 2.17E-09	> 8.66E+00
4*	2.00E+00	< 3.12E-03	< 1.47E-10	< 4.20E-10	< 8.93E-03	< 3.30E-02	< 2.10E-09	> 8.68E+00
5*	3.00E+00	< 4.45E-03	< 2.64E-10	< 7.56E-10	< 1.27E-02	< 4.58E-02	< 1.16E-08	> 7.94E+00
6*	4.00E+00	< 3.18E-03	< 2.03E-10	< 5.82E-10	< 9.09E-03	< 5.49E-02	< 9.63E-09	> 8.02E+00
7*	5.01E+00	< 3.75E-03	< 2.37E-10	< 6.80E-10	< 1.07E-02	< 6.56E-02	< 1.70E-08	> 7.77E+00
8*	1.81E+01	< 3.20E-03	< 1.57E-11	< 4.48E-11	< 9.17E-03	< 7.47E-02	< 1.73E-10	> 9.76E+00
9*	4.60E+01	< 2.87E-03	< 6.58E-12	< 1.88E-11	< 8.22E-03	< 8.30E-02	< 8.84E-11	> 1.01E+01
10*	9.11E+01	< 3.95E-03	< 5.60E-12	< 1.60E-11	< 1.13E-02	< 9.43E-02	< 1.40E-10	> 9.85E+00
11*	1.70E+02	< 3.32E-03	< 2.78E-12	< 7.94E-12	< 9.51E-03	< 1.04E-01	< 6.58E-11	> 1.02E+01
12*	2.01E+02	< 5.70E-03	< 1.27E-11	< 3.64E-11	< 1.63E-02	< 1.20E-01	< 2.00E-09	> 8.70E+00
=====								
		Mean:	< 2.65E-10	< 7.60E-10				
		Standard Deviation:	1.25E-10	3.58E-10				
							< 4.27E-09	> 8.88E+00
							1.58E-09	2.47E-01

TABLE G-7. Radionuclide and stable metal leaching data for Brunswick-1 mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with pH 10.4. (continued)

Co-60

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	9.55E-04	7.29E-10	4.47E-11	5.85E-05	5.85E-05	3.45E-13	1.25E+01
2*	2.93E-01	4.77E-04	8.41E-11	5.15E-12	2.92E-05	8.78E-05	3.76E-14	1.34E+01
3*	1.00E+00	5.65E-04	3.75E-11	2.30E-12	3.46E-05	1.22E-04	2.57E-14	1.36E+01
4*	2.00E+00	1.97E-04	9.26E-12	5.67E-13	1.21E-05	1.34E-04	3.84E-15	1.44E+01
5*	3.00E+00	1.99E-04	1.18E-11	7.24E-13	1.22E-05	1.47E-04	1.06E-14	1.40E+01
6*	4.00E+00	1.37E-04	8.78E-12	5.38E-13	8.42E-06	1.55E-04	8.24E-15	1.41E+01
7*	5.01E+00	1.40E-04	8.86E-12	5.43E-13	8.57E-06	1.64E-04	1.08E-14	1.40E+01
8*	1.81E+01	3.40E-04	1.66E-12	1.02E-13	2.08E-05	1.84E-04	8.92E-16	1.50E+01
9*	4.60E+01	2.77E-04	6.34E-13	3.89E-14	1.70E-05	2.01E-04	3.76E-16	1.54E+01
10*	9.11E+01	2.65E-04	3.75E-13	2.30E-14	1.62E-05	2.18E-04	2.87E-16	1.55E+01
11*	1.70E+02	2.84E-04	2.37E-13	1.46E-14	1.74E-05	2.35E-04	2.21E-16	1.57E+01
12*	2.01E+02	1.41E-04	3.14E-13	1.93E-14	8.64E-06	2.44E-04	5.62E-16	1.53E+01
		Mean:	7.44E-11	4.56E-12			3.70E-14	1.44E+01
		Standard Deviation:	5.99E-11	3.67E-12			2.82E-14	2.87E-01

Ni-63

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.93E-01	1.08E-04	1.90E-11	3.69E-12	2.09E-05	NA	1.93E-14	1.37E+01
3*	1.00E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.00E+00	1.08E-04	5.08E-12	9.90E-13	2.10E-05	NA	1.17E-14	1.39E+01
5*	3.00E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.00E+00	1.00E-04	6.40E-12	1.25E-12	1.95E-05	NA	4.41E-14	1.34E+01
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.81E+01	8.33E-05	4.07E-13	7.93E-14	1.62E-05	NA	5.41E-16	1.53E+01
9*	4.60E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.11E+01	1.41E-04	2.00E-13	3.89E-14	2.75E-05	NA	8.24E-16	1.51E+01
11*	1.70E+02	NA	NA	NA	NA	NA	NA	NA
12*	2.01E+02	NA	NA	NA	NA	NA	NA	NA
(90 Days)		Mean:	6.21E-12	1.21E-12			1.53E-14	1.43E+01
		Standard Deviation:	3.42E-12	6.66E-13			8.03E-15	3.82E-01

Zn-65

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	< 2.04E-04	< 1.56E-10	< 6.57E-10	< 8.61E-04	< 8.61E-04	< 7.47E-11	> 1.01E+01
2*	2.93E-01	< 1.39E-04	< 2.45E-11	< 1.03E-10	< 5.85E-04	< 1.45E-03	< 1.51E-11	> 1.08E+01
3*	1.00E+00	< 2.50E-04	< 1.66E-11	< 7.01E-11	< 1.05E-03	< 2.50E-03	< 2.39E-11	> 1.06E+01
4*	2.00E+00	< 1.41E-04	< 6.62E-12	< 2.79E-11	< 5.94E-04	< 3.09E-03	< 9.31E-12	> 1.10E+01
5*	3.00E+00	< 4.05E-04	< 2.40E-11	< 1.01E-10	< 1.71E-03	< 4.80E-03	< 2.08E-10	> 9.68E+00
6*	4.00E+00	< 1.66E-04	< 1.06E-11	< 4.49E-11	< 7.02E-04	< 5.51E-03	< 5.73E-11	> 1.02E+01
7*	5.01E+00	< 3.24E-04	< 2.05E-11	< 8.66E-11	< 1.37E-03	< 6.87E-03	< 2.75E-10	> 9.56E+00
8*	1.81E+01	< 2.17E-04	< 1.06E-12	< 4.48E-12	< 9.15E-04	< 7.79E-03	< 1.72E-12	> 1.18E+01
9*	4.60E+01	< 1.63E-04	< 3.74E-13	< 1.58E-12	< 6.89E-04	< 8.48E-03	< 6.20E-13	> 1.22E+01
10*	9.11E+01	< 1.67E-04	< 2.36E-13	< 9.97E-13	< 7.04E-04	< 9.18E-03	< 5.41E-13	> 1.23E+01
11*	1.70E+02	< 1.64E-04	< 1.37E-13	< 5.79E-13	< 6.93E-04	< 9.87E-03	< 3.49E-13	> 1.25E+01
12*	2.01E+02	< 1.83E-04	< 4.07E-13	< 1.72E-12	< 7.71E-04	< 1.06E-02	< 4.48E-12	> 1.13E+01
		Mean:	< 2.17E-11	< 9.17E-11			< 5.60E-11	> 1.10E+01
		Standard Deviation:	1.25E-11	5.27E-11			2.63E-11	2.91E-01

TABLE G-7. Radionuclide and stable metal leaching data for Brunswick-1 mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with pH 10.4. (continued)

Sr-90

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	3.01E-05	2.30E-11	2.35E-10	3.08E-04	3.08E-04	9.56E-12	1.10E+01
2*	2.93E-01	6.10E-05	1.08E-11	1.10E-10	6.25E-04	9.33E-04	1.72E-11	1.08E+01
3*	1.00E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.00E+00	6.06E-05	2.85E-12	2.92E-11	6.20E-04	NA	1.01E-11	1.10E+01
5*	3.00E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.00E+00	9.57E-05	6.12E-12	6.27E-11	9.80E-04	NA	1.12E-10	9.95E+00
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.81E+01	5.61E-05	2.74E-13	2.81E-12	5.74E-04	NA	6.79E-13	1.22E+01
9*	4.60E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.11E+01	4.16E-05	5.89E-14	6.03E-13	4.26E-04	NA	1.98E-13	1.27E+01
11*	1.70E+02	NA	NA	NA	NA	NA	NA	NA
12*	2.01E+02	NA	NA	NA	NA	NA	NA	NA
=====								
(90 Days)		Mean:	7.17E-12	7.34E-11				
		Standard Deviation:	3.56E-12	3.64E-11				
							2.49E-11	1.13E+01
							1.76E-11	4.08E-01

Sb-125

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	7.88E-04	6.02E-10	9.59E-10	1.26E-03	1.26E-03	1.59E-10	9.80E+00
2*	2.93E-01	4.13E-04	7.28E-11	1.16E-10	6.58E-04	1.91E-03	1.90E-11	1.07E+01
3*	1.00E+00	7.03E-04	4.67E-11	7.45E-11	1.12E-03	3.04E-03	2.69E-11	1.06E+01
4*	2.00E+00	3.74E-04	1.76E-11	2.80E-11	5.96E-04	3.63E-03	9.37E-12	1.10E+01
5*	3.00E+00	3.90E-04	2.32E-11	3.69E-11	6.22E-04	4.25E-03	2.76E-11	1.06E+01
6*	4.00E+00	1.85E-04	1.18E-11	1.88E-11	2.94E-04	4.55E-03	1.01E-11	1.10E+01
7*	5.01E+00	< 2.22E-04	< 1.41E-11	< 2.24E-11	< 3.54E-04	< 4.90E-03	< 1.84E-11	> 1.07E+01
8*	1.81E+01	2.08E-04	1.02E-12	1.62E-12	3.31E-04	< 5.23E-03	2.26E-13	1.26E+01
9*	4.60E+01	2.19E-04	5.01E-13	7.99E-13	3.49E-04	< 5.58E-03	1.59E-13	1.28E+01
10*	9.11E+01	1.22E-04	1.73E-13	2.76E-13	1.95E-04	< 5.78E-03	4.14E-14	1.34E+01
11*	1.70E+02	2.23E-04	1.86E-13	2.97E-13	3.55E-04	< 6.13E-03	9.20E-14	1.30E+01
12*	2.01E+02	3.92E-04	8.73E-13	1.39E-12	6.24E-04	< 6.76E-03	2.93E-12	1.15E+01
=====								
		Mean:	6.59E-11	1.05E-10				
		Standard Deviation:	4.91E-11	7.83E-11				
							2.28E-11	1.15E+01
							1.28E-11	3.40E-01

Cs-134

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	1.86E-04	1.42E-10	1.64E-08	2.15E-02	2.15E-02	4.64E-08	7.33E+00
2*	2.93E-01	7.84E-05	1.38E-11	1.59E-09	9.02E-03	3.05E-02	3.58E-09	8.45E+00
3*	1.00E+00	< 1.18E-04	< 7.85E-12	< 9.04E-10	< 1.36E-02	< 4.41E-02	< 3.97E-09	> 8.40E+00
4*	2.00E+00	6.34E-05	2.98E-12	3.43E-10	7.30E-03	< 5.14E-02	1.40E-09	8.85E+00
5*	3.00E+00	< 5.90E-05	< 3.50E-12	< 4.03E-10	< 6.78E-03	< 5.82E-02	< 3.28E-09	> 8.48E+00
6*	4.00E+00	< 2.49E-05	< 1.60E-12	< 1.84E-10	< 2.87E-03	< 6.10E-02	< 9.59E-10	> 9.02E+00
7*	5.01E+00	< 6.28E-05	< 3.98E-12	< 4.58E-10	< 7.22E-03	< 6.82E-02	< 7.69E-09	> 8.11E+00
8*	1.81E+01	< 5.75E-05	< 2.81E-13	< 3.23E-11	< 6.61E-03	< 7.49E-02	< 9.00E-11	> 1.00E+01
9*	4.60E+01	< 6.98E-05	< 1.60E-13	< 1.84E-11	< 8.03E-03	< 8.29E-02	< 8.43E-11	> 1.01E+01
10*	9.11E+01	< 4.93E-05	< 6.98E-14	< 8.03E-12	< 5.67E-03	< 8.86E-02	< 3.51E-11	> 1.05E+01
11*	1.70E+02	< 5.52E-05	< 4.61E-14	< 5.31E-12	< 6.35E-03	< 9.49E-02	< 2.94E-11	> 1.05E+01
12*	2.01E+02	< 5.32E-05	< 1.19E-13	< 1.36E-11	< 6.12E-03	< 1.01E-01	< 2.82E-10	> 9.55E+00
=====								
		Mean:	< 1.47E-11	< 1.69E-09				
		Standard Deviation:	1.17E-11	1.34E-09				
							< 5.65E-09	> 9.11E+00
							3.76E-09	2.94E-01

TABLE G-7. Radionuclide and stable metal leaching data for Brunswick-1 mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with pH 10.4. (continued)

Cs-137

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	2.27E-03	1.74E-09	3.83E-08	5.02E-02	5.02E-02	2.54E-07	6.60E+00
2*	2.93E-01	1.05E-03	1.85E-10	4.07E-09	2.31E-02	7.33E-02	2.35E-08	7.63E+00
3*	1.00E+00	1.62E-03	1.08E-10	2.38E-09	3.58E-02	1.09E-01	2.74E-08	7.56E+00
4*	2.00E+00	8.12E-04	3.82E-11	8.43E-10	1.79E-02	1.27E-01	8.47E-09	8.07E+00
5*	3.00E+00	3.31E-04	1.97E-11	4.34E-10	7.31E-03	1.34E-01	3.80E-09	8.42E+00
6*	4.00E+00	1.80E-04	1.15E-11	2.55E-10	3.98E-03	1.38E-01	1.84E-09	8.73E+00
7*	5.01E+00	1.68E-04	1.06E-11	2.35E-10	3.71E-03	1.42E-01	2.02E-09	8.69E+00
8*	1.81E+01	3.52E-04	1.72E-12	3.80E-11	7.76E-03	1.50E-01	1.24E-10	9.91E+00
9*	4.60E+01	2.50E-04	5.73E-13	1.26E-11	5.52E-03	1.55E-01	3.98E-11	1.04E+01
10*	9.11E+01	1.98E-04	2.80E-13	6.18E-12	4.37E-03	1.60E-01	2.08E-11	1.07E+01
11*	1.70E+02	8.05E-05	6.73E-14	1.48E-12	1.78E-03	1.61E-01	2.30E-12	1.16E+01
12*	2.01E+02	4.40E-05	9.81E-14	2.16E-12	9.70E-04	1.62E-01	7.09E-12	1.11E+01
Mean:			1.76E-10	3.88E-09			2.67E-08	9.12E+00
Standard Deviation:			1.43E-10	3.15E-09			2.08E-08	4.61E-01

Pu-241

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.93E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.00E+00	3.00E-05	1.99E-12	8.03E-12	1.21E-04	NA	3.13E-13	1.25E+01
4*	2.00E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.00E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.00E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.60E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.11E+01	NA	NA	NA	NA	NA	NA	NA
Mean:			NA	NA			NA	NA
Standard Deviation:			NA	NA			NA	NA

Fe

SAMPLE NUMBER	TOTAL TIME (days)	QUANTITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	< 7.72E+02	< 5.90E-04	< 7.09E-09	< 9.29E-03	< 9.29E-03	< 8.70E-09	> 8.06E+00
2*	2.93E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.00E+00	< 8.03E+02	< 5.33E-05	< 6.41E-10	< 9.65E-03	NA	< 2.00E-09	> 8.70E+00
4*	2.00E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.00E+00	< 7.95E+02	< 4.72E-05	< 5.67E-10	< 9.56E-03	NA	< 6.51E-09	> 8.19E+00
6*	4.00E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.01E+00	< 8.10E+02	< 5.13E-05	< 6.17E-10	< 9.74E-03	NA	< 1.40E-08	> 7.85E+00
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.60E+01	< 8.06E+02	< 1.85E-06	< 2.22E-11	< 9.69E-03	NA	< 1.23E-10	> 9.91E+00
10*	9.11E+01	NA	NA	NA	NA	NA	NA	NA
(90 days) Mean:			< 1.49E-04	< 1.79E-09			< 6.26E-09	> 8.54E+00
Standard Deviation:			1.11E-04	1.33E-09			2.46E-09	3.69E-01

TABLE G-7. Radionuclide and stable metal leaching data for Brunswick-1 mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with pH 10.4. (continued)

Ni

SAMPLE NUMBER	TOTAL TIME (days)	QUANTITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	< 4.12E+02	< 3.14E-04	< 4.05E-08	< 5.30E-02	< 5.30E-02	< 2.83E-07	> 6.55E+00
2*	2.93E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.00E+00	< 4.28E+02	< 2.84E-05	< 3.66E-09	< 5.51E-02	NA	< 6.50E-08	> 7.19E+00
4*	2.00E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.00E+00	< 4.24E+02	< 2.52E-05	< 3.24E-09	< 5.46E-02	NA	< 2.12E-07	> 6.67E+00
6*	4.00E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.01E+00	< 4.32E+02	< 2.74E-05	< 3.52E-09	< 5.56E-02	NA	< 4.55E-07	> 6.34E+00
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.60E+01	< 4.30E+02	< 9.86E-07	< 1.27E-10	< 5.53E-02	NA	< 4.00E-09	> 8.40E+00
10*	9.11E+01	NA	NA	NA	NA	NA	NA	NA
=====								
(90 days)		Mean:	< 7.93E-05	< 1.02E-08			< 2.04E-07	> 7.03E+00
Standard Deviation:			5.90E-05	7.59E-09			8.02E-08	3.69E-01

Co

SAMPLE NUMBER	TOTAL TIME (days)	QUANTITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	< 5.15E+02	< 3.93E-04	< 1.09E-08	< 1.43E-02	< 1.43E-02	< 2.07E-08	> 7.68E+00
2*	2.93E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.00E+00	< 5.35E+02	< 3.55E-05	< 9.90E-10	< 1.49E-02	NA	< 4.76E-09	> 8.32E+00
4*	2.00E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.00E+00	< 5.30E+02	< 3.15E-05	< 8.76E-10	< 1.48E-02	NA	< 1.55E-08	> 7.81E+00
6*	4.00E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.01E+00	< 5.40E+02	< 3.42E-05	< 9.53E-10	< 1.50E-02	NA	< 3.33E-08	> 7.48E+00
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.60E+01	< 5.38E+02	< 1.23E-06	< 3.43E-11	< 1.50E-02	NA	< 2.93E-10	> 9.53E+00
10*	9.11E+01	NA	NA	NA	NA	NA	NA	NA
=====								
(90 days)		Mean:	< 9.91E-05	< 2.76E-09			< 1.49E-08	> 8.16E+00
Standard Deviation:			7.38E-05	2.05E-09			5.88E-09	3.69E-01

Cr

SAMPLE NUMBER	TOTAL TIME (days)	QUANTITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	< 1.03E+02	< 7.86E-05	< 4.12E-10	< 5.39E-04	< 5.39E-04	< 2.93E-11	> 1.05E+01
2*	2.93E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.00E+00	< 1.07E+02	< 7.11E-06	< 3.72E-11	< 5.60E-04	NA	< 6.73E-12	> 1.12E+01
4*	2.00E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.00E+00	< 1.06E+02	< 6.29E-06	< 3.29E-11	< 5.55E-04	NA	< 2.20E-11	> 1.07E+01
6*	4.00E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.01E+00	< 1.08E+02	< 6.84E-06	< 3.58E-11	< 5.65E-04	NA	< 4.71E-11	> 1.03E+01
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.60E+01	< 1.08E+02	< 2.46E-07	< 1.29E-12	< 5.63E-04	NA	< 4.14E-13	> 1.24E+01
10*	9.11E+01	NA	NA	NA	NA	NA	NA	NA
=====								
(90 days)		Mean:	< 1.98E-05	< 1.04E-10			< 2.11E-11	> 1.10E+01
Standard Deviation:			1.48E-05	7.72E-11			8.30E-12	3.69E-01

TABLE G-8. Radionuclide and stable metal leaching data for Brunswick-1 mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with pH 4.2.

Mn-54

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	< 1.08E-04	< 7.27E-11	< 2.55E-11	< 3.79E-05	< 3.79E-05	< 1.30E-13	> 1.29E+01
2*	2.92E-01	7.33E-05	1.17E-11	4.10E-12	2.57E-05	< 6.36E-05	2.76E-14	1.36E+01
3*	1.00E+00	9.54E-05	5.23E-12	1.83E-12	3.34E-05	< 9.70E-05	1.89E-14	1.37E+01
4*	2.00E+00	< 7.28E-05	< 2.83E-12	< 9.91E-13	< 2.55E-05	< 1.22E-04	< 1.36E-14	> 1.39E+01
5*	3.00E+00	< 7.41E-05	< 2.88E-12	< 1.01E-12	< 2.60E-05	< 1.48E-04	< 2.40E-14	> 1.36E+01
6*	4.00E+00	< 1.03E-04	< 5.31E-12	< 1.86E-12	< 3.60E-05	< 1.84E-04	< 1.15E-13	> 1.29E+01
7*	5.02E+00	< 6.96E-05	< 4.48E-12	< 1.57E-12	< 2.44E-05	< 2.09E-04	< 1.05E-13	> 1.30E+01
8*	1.81E+01	< 7.39E-05	< 3.78E-13	< 1.32E-13	< 2.59E-05	< 2.35E-04	< 1.76E-15	> 1.48E+01
9*	4.60E+01	< 1.03E-04	< 2.47E-13	< 8.65E-14	< 3.60E-05	< 2.71E-04	< 2.16E-15	> 1.47E+01
10*	9.10E+01	< 8.03E-05	< 1.21E-13	< 4.23E-14	< 2.81E-05	< 2.99E-04	< 1.13E-15	> 1.49E+01
11*	1.70E+02	< 6.73E-05	< 5.81E-14	< 2.03E-14	< 2.36E-05	< 3.22E-04	< 5.02E-16	> 1.53E+01
12*	2.01E+02	< 1.15E-04	< 2.56E-13	< 8.97E-14	< 4.04E-05	< 3.63E-04	< 1.42E-14	> 1.38E+01
Mean: < 8.85E-12 < 3.10E-12								< 3.78E-14 > 1.39E+01
Standard Deviation: 5.89E-12 2.06E-12								1.40E-14 2.37E-01

Fe-55

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.92E-01	6.74E-04	1.08E-10	5.69E-12	3.57E-05	NA	5.32E-14	1.33E+01
3*	1.00E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.00E+00	1.04E-03	4.03E-11	2.13E-12	5.48E-05	NA	6.29E-14	1.32E+01
5*	3.00E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.00E+00	9.08E-04	4.69E-11	2.48E-12	4.80E-05	NA	2.04E-13	1.27E+01
7*	5.02E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.81E+01	4.02E-05	2.05E-13	1.09E-14	2.12E-06	NA	1.18E-17	1.69E+01
9*	4.60E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.10E+01	7.84E-05	1.18E-13	6.24E-15	4.15E-06	NA	2.46E-17	1.66E+01
11*	1.70E+02	NA	NA	NA	NA	NA	NA	NA
12*	2.01E+02	NA	NA	NA	NA	NA	NA	NA
(90 Days) Mean: 3.90E-11 2.06E-12								6.40E-14 1.45E+01
Standard Deviation: 1.97E-11 1.04E-12								3.73E-14 9.16E-01

Co-58

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	< 2.21E-03	< 1.48E-09	< 3.94E-09	< 5.86E-03	< 5.86E-03	< 3.10E-09	> 8.51E+00
2*	2.92E-01	< 3.99E-03	< 6.37E-10	< 1.69E-09	< 1.06E-02	< 1.64E-02	< 4.68E-09	> 8.33E+00
3*	1.00E+00	< 3.06E-03	< 1.68E-10	< 4.46E-10	< 8.13E-03	< 2.46E-02	< 1.12E-09	> 8.95E+00
4*	2.00E+00	< 2.27E-03	< 8.80E-11	< 2.34E-10	< 6.02E-03	< 3.06E-02	< 7.57E-10	> 9.12E+00
5*	3.00E+00	< 3.36E-03	< 1.31E-10	< 3.47E-10	< 8.93E-03	< 3.95E-02	< 2.83E-09	> 8.55E+00
6*	4.00E+00	< 2.30E-03	< 1.19E-10	< 3.15E-10	< 6.10E-03	< 4.56E-02	< 3.29E-09	> 8.48E+00
7*	5.02E+00	< 2.54E-03	< 1.64E-10	< 4.34E-10	< 6.74E-03	< 5.24E-02	< 8.06E-09	> 8.09E+00
8*	1.81E+01	< 2.79E-03	< 1.43E-11	< 3.78E-11	< 7.40E-03	< 5.98E-02	< 1.44E-10	> 9.84E+00
9*	4.60E+01	< 4.31E-03	< 1.03E-11	< 2.75E-11	< 1.14E-02	< 7.12E-02	< 2.18E-10	> 9.66E+00
10*	9.10E+01	< 3.04E-03	< 4.57E-12	< 1.21E-11	< 8.06E-03	< 7.93E-02	< 9.30E-11	> 1.00E+01
11*	1.70E+02	< 3.05E-03	< 2.64E-12	< 7.00E-12	< 8.11E-03	< 8.74E-02	< 5.94E-11	> 1.02E+01
12*	2.01E+02	< 3.49E-03	< 7.74E-12	< 2.05E-11	< 9.25E-03	< 9.66E-02	< 7.44E-10	> 9.13E+00
Mean: < 2.36E-10 < 6.26E-10								< 2.09E-09 > 9.08E+00
Standard Deviation: 1.24E-10 3.30E-10								7.03E-10 2.07E-01

TABLE G-8. Radionuclide and stable metal leaching data for Brunswick-1 mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with pH 4.2.

Co-60

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	8.95E-04	6.02E-10	3.42E-11	5.09E-05	5.09E-05	2.34E-13	1.26E+01
2*	2.92E-01	3.25E-04	5.19E-11	2.95E-12	1.85E-05	6.94E-05	1.43E-14	1.38E+01
3*	1.00E+00	1.09E-03	6.00E-11	3.41E-12	6.22E-05	1.32E-04	6.56E-14	1.32E+01
4*	2.00E+00	4.36E-04	1.69E-11	9.63E-13	2.48E-05	1.56E-04	1.28E-14	1.39E+01
5*	3.00E+00	2.98E-04	1.16E-11	6.58E-13	1.69E-05	1.73E-04	1.02E-14	1.40E+01
6*	4.00E+00	1.17E-04	6.02E-12	3.42E-13	6.62E-06	1.80E-04	3.88E-15	1.44E+01
7*	5.02E+00	1.14E-04	7.34E-12	4.17E-13	6.48E-06	1.86E-04	7.44E-15	1.41E+01
8*	1.81E+01	4.39E-04	2.25E-12	1.28E-13	2.50E-05	2.11E-04	1.64E-15	1.48E+01
9*	4.60E+01	2.45E-04	5.88E-13	3.34E-14	1.39E-05	2.25E-04	3.23E-16	1.55E+01
10*	9.10E+01	3.44E-04	5.18E-13	2.94E-14	1.96E-05	2.45E-04	5.48E-16	1.53E+01
11*	1.70E+02	3.28E-04	2.83E-13	1.61E-14	1.86E-05	2.63E-04	3.13E-16	1.55E+01
12*	2.01E+02	1.35E-04	3.00E-13	1.71E-14	7.68E-06	2.71E-04	5.13E-16	1.53E+01
Mean:			6.33E-11	3.60E-12			2.93E-14	1.44E+01
Standard Deviation:			4.93E-11	2.80E-12			1.93E-14	2.68E-01

Ni-63

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.92E-01	2.94E-04	4.69E-11	8.47E-12	5.31E-05	NA	1.18E-13	1.29E+01
3*	1.00E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.00E+00	1.72E-04	6.67E-12	1.20E-12	3.10E-05	NA	2.01E-14	1.37E+01
5*	3.00E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.00E+00	9.06E-05	4.68E-12	8.45E-13	1.63E-05	NA	2.36E-14	1.36E+01
7*	5.02E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.81E+01	1.30E-04	6.65E-13	1.20E-13	2.35E-05	NA	1.44E-15	1.48E+01
9*	4.60E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.10E+01	7.45E-06	1.12E-14	2.02E-15	1.34E-06	NA	2.59E-18	1.76E+01
11*	1.70E+02	NA	NA	NA	NA	NA	NA	NA
12*	2.01E+02	NA	NA	NA	NA	NA	NA	NA
(90 Days) Mean:			1.18E-11	2.13E-12			3.26E-14	1.45E+01
Standard Deviation:			8.87E-12	1.60E-12			2.18E-14	8.22E-01

Zn-65

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	< 2.69E-04	< 1.81E-10	< 7.07E-10	< 1.05E-03	< 1.05E-03	< 1.00E-10	> 1.00E+01
2*	2.92E-01	< 1.33E-04	< 2.13E-11	< 8.33E-11	< 5.22E-04	< 1.57E-03	< 1.14E-11	> 1.09E+01
3*	1.00E+00	< 1.52E-04	< 8.35E-12	< 3.27E-11	< 5.96E-04	< 2.17E-03	< 6.02E-12	> 1.12E+01
4*	2.00E+00	< 1.48E-04	< 5.73E-12	< 2.24E-11	< 5.78E-04	< 2.75E-03	< 6.98E-12	> 1.12E+01
5*	3.00E+00	< 1.98E-04	< 7.69E-12	< 3.01E-11	< 7.75E-04	< 3.52E-03	< 2.13E-11	> 1.07E+01
6*	4.00E+00	< 1.63E-04	< 8.42E-12	< 3.29E-11	< 6.37E-04	< 4.16E-03	< 3.59E-11	> 1.04E+01
7*	5.02E+00	< 2.24E-04	< 1.44E-11	< 5.64E-11	< 8.75E-04	< 5.04E-03	< 1.36E-10	> 9.87E+00
8*	1.81E+01	< 1.59E-04	< 8.12E-13	< 3.18E-12	< 6.21E-04	< 5.66E-03	< 1.01E-12	> 1.20E+01
9*	4.60E+01	< 1.94E-04	< 4.65E-13	< 1.52E-12	< 6.35E-04	< 6.29E-03	< 6.72E-13	> 1.22E+01
10*	9.10E+01	< 1.70E-04	< 2.55E-13	< 9.98E-13	< 6.64E-04	< 6.96E-03	< 6.31E-13	> 1.22E+01
11*	1.70E+02	< 1.51E-04	< 1.30E-13	< 5.09E-13	< 5.89E-04	< 7.54E-03	< 3.14E-13	> 1.25E+01
12*	2.01E+02	< 2.28E-04	< 5.07E-13	< 1.98E-12	< 8.93E-04	< 8.44E-03	< 6.93E-12	> 1.12E+01
Mean:			< 2.07E-11	< 8.11E-11			< 2.73E-11	> 1.12E+01
Standard Deviation:			1.47E-11	5.74E-11			1.28E-11	2.52E-01

TABLE G-8. Radionuclide and stable metal leaching data for Brunswick-1 mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with pH 4.2.

Sr-90

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	8.23E-06	5.53E-12	5.25E-11	7.82E-05	7.82E-05	5.51E-13	1.23E+01
2*	2.92E-01	2.74E-05	4.38E-12	4.16E-11	2.60E-04	3.39E-04	2.84E-12	1.15E+01
3*	1.00E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.00E+00	2.92E-05	1.13E-12	1.08E-11	2.77E-04	NA	1.61E-12	1.18E+01
5*	3.00E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.00E+00	8.63E-06	4.46E-13	4.23E-12	8.19E-05	NA	5.93E-13	1.22E+01
7*	5.02E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.81E+01	< 4.07E-07	< 2.08E-15	< 1.98E-14	< 3.87E-06	NA	< 3.92E-17	> 1.64E+01
9*	4.60E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.10E+01	4.54E-06	6.82E-15	6.47E-14	4.31E-05	NA	2.65E-15	1.46E+01
11*	1.70E+02	NA	NA	NA	NA	NA	NA	NA
12*	2.01E+02	NA	NA	NA	NA	NA	NA	NA
=====								
(90 Days)		Mean:	1.92E-12	1.82E-11			9.32E-13	1.31E+01
Standard Deviation:			9.87E-13	9.37E-12			4.50E-13	7.89E-01

Sb-125

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	7.71E-04	5.18E-10	7.66E-10	1.14E-03	1.14E-03	1.17E-10	9.93E+00
2*	2.92E-01	4.44E-04	7.09E-11	1.05E-10	6.56E-04	1.80E-03	1.80E-11	1.07E+01
3*	1.00E+00	7.08E-04	3.88E-11	5.73E-11	1.05E-03	2.84E-03	1.86E-11	1.07E+01
4*	2.00E+00	4.92E-04	1.91E-11	2.83E-11	7.28E-04	3.57E-03	1.11E-11	1.10E+01
5*	3.00E+00	5.11E-04	1.99E-11	2.94E-11	7.56E-04	4.32E-03	2.03E-11	1.07E+01
6*	4.00E+00	1.04E-04	5.38E-12	7.95E-12	1.54E-04	4.48E-03	2.09E-12	1.17E+01
7*	5.02E+00	1.53E-04	9.84E-12	1.45E-11	2.26E-04	4.70E-03	9.04E-12	1.10E+01
8*	1.81E+01	3.16E-04	1.62E-12	2.39E-12	4.67E-04	5.17E-03	5.72E-13	1.22E+01
9*	4.60E+01	1.91E-04	4.59E-13	6.79E-13	2.83E-04	5.45E-03	1.33E-13	1.29E+01
10*	9.10E+01	3.34E-04	5.03E-13	7.43E-13	4.94E-04	5.95E-03	3.50E-13	1.25E+01
11*	1.70E+02	2.43E-04	2.10E-13	3.10E-13	3.60E-04	6.31E-03	1.17E-13	1.29E+01
12*	2.01E+02	2.28E-04	5.06E-13	7.47E-13	3.37E-04	6.64E-03	9.84E-13	1.20E+01
=====								
Mean:			5.71E-11	8.44E-11			1.65E-11	1.15E+01
Standard Deviation:			4.23E-11	6.26E-11			9.43E-12	2.82E-01

Cs-134

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	3.15E-04	2.11E-10	2.26E-08	3.36E-02	3.36E-02	1.02E-07	6.99E+00
2*	2.92E-01	1.87E-04	2.98E-11	3.18E-09	1.99E-02	5.35E-02	1.66E-08	7.78E+00
3*	1.00E+00	2.63E-04	1.44E-11	1.54E-09	2.80E-02	8.16E-02	1.34E-08	7.87E+00
4*	2.00E+00	1.67E-04	6.48E-12	6.91E-10	1.78E-02	9.93E-02	6.62E-09	8.18E+00
5*	3.00E+00	7.01E-05	2.72E-12	2.90E-10	7.48E-03	1.07E-01	1.99E-09	8.70E+00
6*	4.00E+00	< 5.96E-05	< 3.08E-12	< 3.28E-10	< 6.36E-03	< 1.13E-01	< 3.57E-09	> 8.45E+00
7*	5.02E+00	< 5.71E-05	< 3.68E-12	< 3.92E-10	< 6.09E-03	< 1.19E-01	< 6.57E-09	> 8.18E+00
8*	1.81E+01	< 5.45E-05	< 2.79E-13	< 2.97E-11	< 5.81E-03	< 1.25E-01	< 8.87E-11	> 1.01E+01
9*	4.60E+01	< 5.45E-05	< 1.31E-13	< 1.39E-11	< 5.81E-03	< 1.31E-01	< 5.63E-11	> 1.02E+01
10*	9.10E+01	< 5.90E-05	< 8.87E-14	< 9.46E-12	< 6.30E-03	< 1.37E-01	< 5.67E-11	> 1.02E+01
11*	1.70E+02	< 4.72E-05	< 4.08E-14	< 4.35E-12	< 5.04E-03	< 1.42E-01	< 2.30E-11	> 1.06E+01
12*	2.01E+02	< 3.56E-05	< 7.89E-14	< 8.42E-12	< 3.79E-03	< 1.46E-01	< 1.25E-10	> 9.90E+00
=====								
Mean:			< 2.27E-11	< 2.42E-09			< 1.26E-08	> 8.94E+00
Standard Deviation:			1.73E-11	1.85E-09			8.26E-09	3.50E-01

TABLE G-8. Radionuclide and stable metal leaching data for Brunswick-1 mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with pH 4.2.

Cs-137

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	3.22E-03	2.17E-09	4.43E-08	6.59E-02	6.59E-02	3.92E-07	6.41E+00
2*	2.92E-01	1.89E-03	3.01E-10	6.16E-09	3.86E-02	1.04E-01	6.22E-08	7.21E+00
3*	1.00E+00	2.88E-03	1.58E-10	3.23E-09	5.89E-02	1.63E-01	5.90E-08	7.23E+00
4*	2.00E+00	1.74E-03	8.75E-11	1.38E-09	3.55E-02	1.99E-01	2.64E-08	7.58E+00
5*	3.00E+00	6.56E-04	2.55E-11	5.21E-10	1.34E-02	2.12E-01	2.01E-07	6.70E+00
6*	4.00E+00	1.51E-04	7.78E-12	1.59E-10	3.08E-03	2.15E-01	1.55E-07	6.81E+00
7*	5.02E+00	1.67E-04	1.07E-11	2.20E-10	3.41E-03	2.19E-01	1.29E-07	6.89E+00
8*	1.81E+01	5.05E-04	2.58E-12	5.29E-11	1.03E-02	2.29E-01	3.93E-08	7.41E+00
9*	4.60E+01	3.36E-04	8.05E-13	1.65E-11	6.86E-03	2.36E-01	1.63E-08	7.79E+00
10*	9.10E+01	2.56E-04	3.85E-13	7.88E-12	5.24E-03	2.41E-01	8.77E-09	8.06E+00
11*	1.70E+02	1.58E-04	1.36E-13	2.79E-12	3.23E-03	2.45E-01	4.87E-09	8.31E+00
12*	2.01E+02	5.63E-05	1.25E-13	2.56E-12	1.15E-03	2.46E-01	4.14E-09	8.38E+00
Mean:			2.28E-10	4.67E-09			9.15E-08	7.40E+00
Standard Deviation:			1.78E-10	3.64E-09			3.31E-08	1.86E-01

Pu-241

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.92E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.00E+00	4.49E-05	2.46E-12	9.22E-12	1.68E-04	NA	4.80E-13	1.23E+01
4*	2.00E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.00E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.00E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.02E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.60E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
Mean:			NA	NA			NA	NA
Standard Deviation:			NA	NA			NA	NA

Fe

SAMPLE NUMBER	TOTAL TIME (days)	TOTAL LEACHED (ug)	RELEASE RATE (uG/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	< 6.86E+02	< 4.61E-04	< 5.14E-09	< 7.65E-03	< 7.65E-03	< 5.28E-09	> 8.28E+00
2*	2.92E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.00E+00	< 7.20E+02	< 3.95E-05	< 4.40E-10	< 8.03E-03	NA	< 1.09E-09	> 8.96E+00
4*	2.00E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.00E+00	< 7.54E+02	< 2.93E-05	< 3.26E-10	< 8.40E-03	NA	< 2.51E-09	> 8.60E+00
6*	4.00E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.02E+00	< 7.28E+02	< 4.69E-05	< 5.23E-10	< 8.11E-03	NA	< 1.17E-08	> 7.93E+00
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.60E+01	< 7.28E+02	< 1.74E-06	< 1.95E-11	< 8.11E-03	NA	< 1.10E-10	> 9.96E+00
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
(90 days)		Mean:	< 1.16E-04	< 1.29E-09			< 4.13E-09	> 8.75E+00
		Standard Deviation:	8.67E-05	9.66E-10			2.08E-09	3.48E-01

TABLE G-8. Radionuclide and stable metal leaching data for Brunswick-1 mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with pH 4.2.

Ni

SAMPLE NUMBER	TOTAL TIME (days)	TOTAL LEACHED (ug)	RELEASE RATE (uG/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	< 3.66E+02	< 2.46E-04	< 2.93E-08	< 4.37E-02	< 4.37E-02	< 1.72E-07	> 6.76E+00
2*	2.92E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.00E+00	< 3.84E+02	< 2.11E-05	< 2.51E-09	< 4.58E-02	NA	< 3.56E-08	> 7.45E+00
4*	2.00E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.00E+00	< 4.02E+02	< 1.56E-05	< 1.86E-09	< 4.80E-02	NA	< 8.17E-08	> 7.09E+00
6*	4.00E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.02E+00	< 3.88E+02	< 2.50E-05	< 2.98E-09	< 4.63E-02	NA	< 3.80E-07	> 6.42E+00
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.60E+01	< 3.88E+02	< 9.31E-07	< 1.11E-10	< 4.63E-02	NA	< 3.57E-09	> 8.45E+00
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
(90 days)		Mean:	< 6.17E-05	< 7.36E-09			< 1.35E-07	> 7.23E+00
Standard Deviation:			4.62E-05	5.52E-09			6.76E-08	3.48E-01

Co

SAMPLE NUMBER	TOTAL TIME (days)	TOTAL LEACHED (ug)	RELEASE RATE (uG/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	< 4.58E+02	< 3.07E-04	< 7.94E-09	< 1.18E-02	< 1.18E-02	< 1.26E-08	> 7.90E+00
2*	2.92E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.00E+00	5.76E+01	3.16E-06	8.16E-11	1.49E-03	NA	3.76E-11	1.04E+01
4*	2.00E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.00E+00	< 5.03E+02	< 1.95E-05	< 5.04E-10	< 1.30E-02	NA	< 5.98E-09	> 8.22E+00
6*	4.00E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.02E+00	< 4.85E+02	< 3.12E-05	< 8.07E-10	< 1.25E-02	NA	< 2.78E-08	> 7.56E+00
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.60E+01	< 4.85E+02	< 1.16E-06	< 3.00E-11	< 1.25E-02	NA	< 2.61E-10	> 9.58E+00
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
(90 days)		Mean:	< 7.25E-05	< 1.87E-09			< 9.34E-09	> 8.74E+00
Standard Deviation:			5.90E-05	1.52E-09			5.16E-09	5.44E-01

Cr

SAMPLE NUMBER	TOTAL TIME (days)	TOTAL LEACHED (ug)	RELEASE RATE (uG/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	< 9.15E+01	< 6.15E-05	< 2.98E-10	< 4.44E-04	< 4.44E-04	< 1.78E-11	> 1.07E+01
2*	2.92E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.00E+00	< 9.60E+01	< 5.26E-06	< 2.56E-11	< 4.66E-04	NA	< 3.69E-12	> 1.14E+01
4*	2.00E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.00E+00	< 1.01E+02	< 3.90E-06	< 1.89E-11	< 4.88E-04	NA	< 8.46E-12	> 1.11E+01
6*	4.00E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.02E+00	< 9.70E+01	< 6.25E-06	< 3.03E-11	< 4.71E-04	NA	< 3.93E-11	> 1.04E+01
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.60E+01	< 9.70E+01	< 2.33E-07	< 1.13E-12	< 4.71E-04	NA	< 3.69E-13	> 1.24E+01
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
(90 days)		Mean:	< 1.54E-05	< 7.49E-11			< 1.39E-11	> 1.12E+01
Standard Deviation:			1.16E-05	5.61E-11			7.00E-12	3.48E-01

TABLE G-9. Radionuclide and stable metal leaching data for Brunswick-1 mixed-bed resin waste-form specimen leached in synthetic Hanford ground water with pH 8.9.

Mn-54

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	9.18E-04	3.74E-10	1.68E-10	4.12E-04	4.12E-04	3.48E-12	1.15E+01
2*	2.94E-01	< 1.11E-04	< 1.85E-11	< 8.30E-12	< 4.97E-05	< 4.62E-04	< 6.94E-14	> 1.32E+01
3*	1.00E+00	< 1.23E-04	< 6.29E-12	< 2.82E-12	< 5.51E-05	< 5.17E-04	< 2.75E-14	> 1.36E+01
4*	2.00E+00	7.76E-04	4.51E-11	2.03E-11	3.48E-04	< 8.65E-04	3.47E-12	1.15E+01
5*	3.00E+00	< 1.31E-04	< 8.79E-12	< 3.95E-12	< 5.90E-05	< 9.24E-04	< 2.23E-13	> 1.27E+01
6*	4.00E+00	< 8.61E-05	< 5.93E-12	< 2.66E-12	< 3.86E-05	< 9.63E-04	< 1.43E-13	> 1.28E+01
7*	5.01E+00	< 1.58E-04	< 1.08E-11	< 4.84E-12	< 7.09E-05	< 1.03E-03	< 6.10E-13	> 1.22E+01
8*	1.81E+01	< 1.06E-04	< 5.60E-13	< 2.51E-13	< 4.77E-05	< 1.08E-03	< 3.85E-15	> 1.44E+01
9*	4.60E+01	< 9.47E-05	< 2.34E-13	< 1.05E-13	< 4.25E-05	< 1.12E-03	< 1.94E-15	> 1.47E+01
10*	9.10E+01	< 1.37E-04	< 2.09E-13	< 9.39E-14	< 6.14E-05	< 1.19E-03	< 3.40E-15	> 1.45E+01
11*	1.70E+02	< 1.11E-04	< 9.69E-14	< 4.35E-14	< 5.00E-05	< 1.24E-03	< 1.40E-15	> 1.49E+01
12*	2.01E+02	< 2.26E-04	< 5.07E-13	< 2.27E-13	< 1.01E-04	< 1.34E-03	< 5.55E-14	> 1.33E+01
Mean: < 3.92E-11 < 1.76E-11								< 6.74E-13 > 1.33E+01
Standard Deviation: 3.06E-11 1.37E-11								3.81E-13 3.44E-01

Fe-55

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.94E-01	2.09E-04	3.48E-11	2.36E-12	1.42E-05	NA	5.62E-15	1.43E+01
3*	1.00E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.00E+00	1.15E-03	6.67E-11	4.52E-12	7.77E-05	NA	1.73E-13	1.28E+01
5*	3.00E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.00E+00	3.74E-03	2.58E-10	1.75E-11	2.54E-04	NA	6.17E-12	1.12E+01
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.81E+01	2.04E-04	1.07E-12	7.27E-14	1.38E-05	NA	3.22E-16	1.55E+01
9*	4.60E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.10E+01	3.42E-04	5.23E-13	3.55E-14	2.32E-05	NA	4.85E-16	1.53E+01
11*	1.70E+02	NA	NA	NA	NA	NA	NA	NA
12*	2.01E+02	NA	NA	NA	NA	NA	NA	NA
(90 Days)		Mean:	7.22E-11	4.90E-12			1.27E-12	1.38E+01
		Standard Deviation:	4.80E-11	3.26E-12			1.23E-12	8.11E-01

Co-58

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	< 1.08E-03	< 4.37E-10	< 1.49E-09	< 3.66E-03	< 3.66E-03	< 2.74E-10	> 9.56E+00
2*	2.94E-01	< 3.76E-03	< 6.27E-10	< 2.13E-09	< 1.28E-02	< 1.64E-02	< 4.58E-09	> 8.34E+00
3*	1.00E+00	< 2.93E-03	< 1.50E-10	< 5.10E-10	< 9.96E-03	< 2.64E-02	< 8.97E-10	> 9.05E+00
4*	2.00E+00	< 3.30E-03	< 1.92E-10	< 6.53E-10	< 1.12E-02	< 3.76E-02	< 3.60E-09	> 8.44E+00
5*	3.00E+00	< 7.16E-03	< 4.79E-10	< 1.63E-09	< 2.43E-02	< 6.19E-02	< 3.81E-08	> 7.42E+00
6*	4.00E+00	< 3.04E-03	< 2.10E-10	< 7.13E-10	< 1.04E-02	< 7.23E-02	< 1.03E-08	> 7.99E+00
7*	5.01E+00	< 4.48E-03	< 3.06E-10	< 1.04E-09	< 1.52E-02	< 8.75E-02	< 2.81E-08	> 7.55E+00
8*	1.81E+01	4.89E-03	2.58E-11	8.76E-11	1.66E-02	< 1.04E-01	4.69E-10	9.33E+00
9*	4.60E+01	< 3.07E-03	< 7.59E-12	< 2.58E-11	< 1.05E-02	< 1.15E-01	< 1.17E-10	> 9.93E+00
10*	9.10E+01	< 3.17E-03	< 4.84E-12	< 1.65E-11	< 1.08E-02	< 1.25E-01	< 1.05E-10	> 9.98E+00
11*	1.70E+02	< 4.91E-03	< 4.27E-12	< 1.45E-11	< 1.67E-02	< 1.42E-01	< 1.56E-10	> 9.81E+00
12*	2.01E+02	< 5.47E-03	< 1.23E-11	< 4.17E-11	< 1.86E-02	< 1.61E-01	< 1.86E-09	> 8.73E+00
Mean: < 2.05E-10 < 6.96E-10								< 7.38E-09 > 8.84E+00
Standard Deviation: 6.21E-11 2.11E-10								3.62E-09 2.62E-01

TABLE 6-9. Radionuclide and stable metal leaching data for Brunswick-1 mixed-bed resin waste-form specimen leached in synthetic Hanford ground water with pH 8.9. (continued)

Co-60

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	5.41E-03	2.20E-09	1.60E-10	3.94E-04	3.94E-04	3.17E-12	1.15E+01
2*	2.94E-01	2.42E-04	4.04E-11	2.94E-12	1.76E-05	4.11E-04	8.73E-15	1.41E+01
3*	1.00E+00	3.88E-04	1.99E-11	1.45E-12	2.82E-05	4.40E-04	7.22E-15	1.41E+01
4*	2.00E+00	4.20E-03	2.44E-10	1.78E-11	3.06E-04	7.46E-04	2.68E-12	1.16E+01
5*	3.00E+00	2.63E-04	1.76E-11	1.28E-12	1.92E-05	7.65E-04	2.36E-14	1.36E+01
6*	4.00E+00	1.25E-04	8.62E-12	6.28E-13	9.11E-06	7.74E-04	7.95E-15	1.41E+01
7*	5.01E+00	7.35E-05	5.01E-12	3.65E-13	5.35E-06	7.79E-04	3.47E-15	1.45E+01
8*	1.81E+01	2.50E-04	1.32E-12	9.59E-14	1.82E-05	7.97E-04	5.62E-16	1.53E+01
9*	4.60E+01	2.48E-04	6.13E-13	4.46E-14	1.81E-05	8.15E-04	3.51E-16	1.55E+01
10*	9.10E+01	3.61E-04	5.52E-13	4.02E-14	2.63E-05	8.42E-04	6.23E-16	1.52E+01
11*	1.70E+02	3.76E-04	3.27E-13	2.38E-14	2.73E-05	8.69E-04	4.18E-16	1.54E+01
12*	2.01E+02	1.97E-04	4.41E-13	3.21E-14	1.43E-05	8.83E-04	1.10E-15	1.50E+01
Mean:			2.12E-10	1.54E-11			4.92E-13	1.41E+01
Standard Deviation:			1.82E-10	1.32E-11			3.30E-13	3.92E-01

Ni-63

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.94E-01	7.64E-04	1.27E-10	2.95E-11	1.77E-04	NA	8.75E-13	1.21E+01
3*	1.00E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.00E+00	1.57E-04	9.14E-12	2.11E-12	3.63E-05	NA	3.78E-14	1.34E+01
5*	3.00E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.00E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.81E+01	1.52E-04	8.01E-13	1.85E-13	3.52E-05	NA	2.10E-15	1.47E+01
9*	4.60E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.10E+01	6.77E-05	1.04E-13	2.40E-14	1.57E-05	NA	2.21E-16	1.57E+01
11*	1.70E+02	NA	NA	NA	NA	NA	NA	NA
12*	2.01E+02	NA	NA	NA	NA	NA	NA	NA
(90 Days) Mean:			3.44E-11	7.95E-12			2.29E-13	1.40E+01
Standard Deviation:			3.11E-11	7.19E-12			2.16E-13	7.80E-01

Zn-65

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	< 4.96E-04	< 2.02E-10	< 1.01E-09	< 2.49E-03	< 2.49E-03	< 1.27E-10	> 9.90E+00
2*	2.94E-01	< 1.50E-04	< 2.51E-11	< 1.26E-10	< 7.54E-04	< 3.24E-03	< 1.59E-11	> 1.08E+01
3*	1.00E+00	< 1.32E-04	< 6.77E-12	< 3.40E-11	< 6.63E-04	< 3.90E-03	< 3.98E-12	> 1.14E+01
4*	2.00E+00	< 3.68E-04	< 2.14E-11	< 1.07E-10	< 1.85E-03	< 5.75E-03	< 9.75E-11	> 1.00E+01
5*	3.00E+00	< 1.62E-04	< 1.08E-11	< 5.43E-11	< 8.11E-04	< 6.56E-03	< 4.22E-11	> 1.04E+01
6*	4.00E+00	< 1.67E-04	< 1.15E-11	< 5.78E-11	< 8.40E-04	< 7.40E-03	< 6.75E-11	> 1.02E+01
7*	5.01E+00	< 1.59E-04	< 1.09E-11	< 5.46E-11	< 7.99E-04	< 8.20E-03	< 7.75E-11	> 1.01E+01
8*	1.81E+01	< 4.34E-04	< 2.28E-12	< 1.15E-11	< 2.17E-03	< 1.04E-02	< 8.01E-12	> 1.11E+01
9*	4.60E+01	< 1.79E-04	< 4.43E-13	< 2.22E-12	< 8.99E-04	< 1.13E-02	< 8.70E-13	> 1.21E+01
10*	9.10E+01	< 2.02E-04	< 3.09E-13	< 1.55E-12	< 1.01E-03	< 1.23E-02	< 9.27E-13	> 1.20E+01
11*	1.70E+02	< 1.67E-04	< 1.45E-13	< 7.28E-13	< 8.36E-04	< 1.31E-02	< 3.91E-13	> 1.24E+01
12*	2.01E+02	< 7.86E-04	< 1.76E-12	< 8.83E-12	< 3.94E-03	< 1.71E-02	< 8.36E-11	> 1.01E+01
Mean:			< 2.45E-11	< 1.23E-10			< 4.38E-11	> 1.09E+01
Standard Deviation:			1.63E-11	8.18E-11			1.30E-11	2.63E-01

TABLE G-9. Radionuclide and stable metal leaching data for Brunswick-1 mixed-bed resin waste-form specimen leached in synthetic Hanford ground water with pH 8.9. (continued)

Sr-90

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	1.53E-05	6.21E-12	7.56E-11	1.86E-04	1.86E-04	7.06E-13	1.22E+01
2*	2.94E-01	< 9.58E-06	< 1.60E-12	< 1.94E-11	< 1.16E-04	< 3.02E-04	< 3.81E-13	> 1.24E+01
3*	1.00E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.00E+00	< 4.64E-06	< 2.70E-13	< 3.28E-12	< 5.64E-05	NA	< 9.11E-14	> 1.30E+01
5*	3.00E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.00E+00	< 9.20E-06	< 6.34E-13	< 7.71E-12	< 1.12E-04	NA	< 1.20E-12	> 1.19E+01
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.81E+01	< 5.78E-06	< 3.04E-14	< 3.70E-13	< 7.03E-05	NA	< 8.36E-15	> 1.41E+01
9*	4.60E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.10E+01	< 4.66E-07	< 7.13E-16	< 8.68E-15	< 5.67E-06	NA	< 2.90E-17	> 1.65E+01
11*	1.70E+02	NA	NA	NA	NA	NA	NA	NA
12*	2.01E+02	NA	NA	NA	NA	NA	NA	NA
=====								
(90 Days)		Mean:	< 1.46E-12	< 1.77E-11			< 3.98E-13	> 1.34E+01
Standard Deviation:			9.81E-13	1.19E-11			1.95E-13	7.10E-01

Sb-125

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	8.04E-04	3.27E-10	6.19E-10	1.52E-03	1.52E-03	4.75E-11	1.03E+01
2*	2.94E-01	3.65E-04	6.08E-11	1.15E-10	6.90E-04	2.21E-03	1.34E-11	1.09E+01
3*	1.00E+00	5.30E-04	2.71E-11	5.14E-11	1.00E-03	3.22E-03	9.11E-12	1.10E+01
4*	2.00E+00	2.08E-04	1.21E-11	2.29E-11	3.94E-04	3.61E-03	4.45E-12	1.14E+01
5*	3.00E+00	2.07E-04	1.38E-11	2.62E-11	3.92E-04	4.00E-03	9.87E-12	1.10E+01
6*	4.00E+00	1.71E-04	1.18E-11	2.24E-11	3.25E-04	4.33E-03	1.01E-11	1.10E+01
7*	5.01E+00	< 1.73E-04	< 1.18E-11	< 2.24E-11	< 3.27E-04	< 4.65E-03	< 1.30E-11	> 1.09E+01
8*	1.81E+01	2.42E-04	1.27E-12	2.41E-12	4.57E-04	< 5.11E-03	3.54E-13	1.25E+01
9*	4.60E+01	< 3.09E-04	< 7.63E-13	< 1.44E-12	< 5.85E-04	< 5.70E-03	< 3.68E-13	> 1.24E+01
10*	9.10E+01	3.08E-04	4.72E-13	8.93E-13	5.84E-04	< 6.28E-03	3.08E-13	1.25E+01
11*	1.70E+02	3.62E-04	3.15E-13	5.96E-13	6.85E-04	< 6.97E-03	2.63E-13	1.26E+01
12*	2.01E+02	5.15E-04	1.15E-12	2.19E-12	9.75E-04	< 7.94E-03	5.13E-12	1.13E+01
=====								
Mean:			3.91E-11	7.39E-11			9.48E-12	1.15E+01
Standard Deviation:			2.67E-11	5.05E-11			3.74E-12	2.28E-01

Cs-134

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	< 1.01E-04	< 4.10E-11	< 5.60E-09	< 1.38E-02	< 1.38E-02	< 3.88E-09	> 8.41E+00
2*	2.94E-01	7.07E-05	1.18E-11	1.61E-09	9.67E-03	< 2.34E-02	2.62E-09	8.58E+00
3*	1.00E+00	1.02E-04	5.23E-12	7.15E-10	1.40E-02	< 3.74E-02	1.76E-09	8.75E+00
4*	2.00E+00	< 6.42E-05	< 3.74E-12	< 5.11E-10	< 8.78E-03	< 4.62E-02	< 2.21E-09	> 8.66E+00
5*	3.00E+00	< 5.03E-05	< 3.37E-12	< 4.60E-10	< 6.87E-03	< 5.30E-02	< 3.04E-09	> 8.52E+00
6*	4.00E+00	< 4.69E-05	< 3.23E-12	< 4.42E-10	< 6.41E-03	< 5.95E-02	< 3.94E-09	> 8.40E+00
7*	5.01E+00	< 5.07E-05	< 3.46E-12	< 4.73E-10	< 6.93E-03	< 6.64E-02	< 5.82E-09	> 8.24E+00
8*	1.81E+01	< 7.57E-05	< 3.99E-13	< 5.45E-11	< 1.03E-02	< 7.67E-02	< 1.81E-10	> 9.74E+00
9*	4.60E+01	< 7.62E-05	< 1.88E-13	< 2.57E-11	< 1.04E-02	< 8.71E-02	< 1.17E-10	> 9.93E+00
10*	9.10E+01	< 3.26E-05	< 4.99E-14	< 6.82E-12	< 4.46E-03	< 9.16E-02	< 1.79E-11	> 1.07E+01
11*	1.70E+02	< 4.46E-05	< 3.88E-14	< 5.30E-12	< 6.09E-03	< 9.77E-02	< 2.08E-11	> 1.07E+01
12*	2.01E+02	< 5.05E-05	< 1.13E-13	< 1.55E-11	< 6.90E-03	< 1.05E-01	< 2.57E-10	> 9.59E+00
=====								
Mean:							< 1.99E-09	> 9.19E+00
Standard Deviation:							5.58E-10	2.63E-01

TABLE G-9. Radionuclide and stable metal leaching data for Brunswick-1 mixed-bed resin waste-form specimen leached in synthetic Hanford ground water with pH 8.9. (continued)

Cs-137

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	1.97E-03	8.00E-10	2.10E-08	5.15E-02	5.15E-02	5.44E-08	7.26E+00
2*	2.94E-01	9.38E-04	1.56E-10	4.10E-09	2.46E-02	7.61E-02	1.69E-08	7.77E+00
3*	1.00E+00	1.40E-03	7.15E-11	1.87E-09	3.66E-02	1.13E-01	1.21E-08	7.92E+00
4*	2.00E+00	3.16E-04	1.84E-11	4.81E-10	8.28E-03	1.21E-01	1.96E-09	8.71E+00
5*	3.00E+00	2.28E-04	1.52E-11	4.00E-10	5.97E-03	1.27E-01	2.29E-09	8.64E+00
6*	4.00E+00	1.42E-04	9.77E-12	2.56E-10	3.72E-03	1.31E-01	1.32E-09	8.88E+00
7*	5.01E+00	1.43E-04	9.74E-12	2.55E-10	3.74E-03	1.34E-01	1.70E-09	8.77E+00
8*	1.81E+01	2.55E-04	1.34E-12	3.52E-11	6.68E-03	1.41E-01	7.56E-11	1.01E+01
9*	4.60E+01	2.33E-04	5.75E-13	1.51E-11	6.10E-03	1.47E-01	4.01E-11	1.04E+01
10*	9.10E+01	1.99E-04	3.05E-13	8.00E-12	5.23E-03	1.52E-01	2.47E-11	1.06E+01
11*	1.70E+02	1.05E-04	9.17E-14	2.40E-12	2.76E-03	1.55E-01	4.26E-12	1.14E+01
12*	2.01E+02	< 8.76E-05	< 1.96E-13	< 5.14E-12	< 2.30E-03	< 1.57E-01	< 2.84E-11	> 1.05E+01
Mean:			9.03E-11	2.37E-09			7.58E-09	9.25E+00
Standard Deviation:			6.59E-11	1.73E-09			4.54E-09	3.80E-01

Pu-241

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.94E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.00E+00	< 2.80E-05	< 1.43E-12	< 6.88E-12	< 1.34E-04	NA	< 1.63E-13	> 1.28E+01
4*	2.00E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.00E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.00E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.60E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
Mean:			NA	NA			NA	NA
Standard Deviation:			NA	NA			NA	NA

Fe

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	< 8.25E+02	< 3.36E-04	< 4.79E-09	< 1.18E-02	< 1.18E-02	< 2.84E-09	> 8.55E+00
2*	2.94E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.00E+00	1.72E+02	8.81E-06	1.26E-10	2.46E-03	1.42E-02	5.46E-11	1.03E+01
4*	2.00E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.00E+00	1.66E+02	1.11E-05	1.58E-10	2.37E-03	1.66E-02	3.59E-10	9.44E+00
6*	4.00E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.01E+00	< 7.95E+02	< 5.43E-05	< 7.75E-10	< 1.14E-02	< 2.80E-02	< 1.56E-08	> 7.81E+00
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.60E+01	< 8.40E+02	< 2.07E-06	< 2.96E-11	< 1.20E-02	< 4.00E-02	< 1.55E-10	> 9.81E+00
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
(90 days) Mean:			< 8.24E-05	< 1.18E-09			< 3.81E-09	> 9.17E+00
Standard Deviation:			6.40E-05	9.14E-10			3.00E-09	4.43E-01

TABLE G-9. Radionuclide and stable metal leaching data for Brunswick-1 mixed-bed resin waste-form specimen leached in synthetic Hanford ground water with pH 8.9. (continued)

Ni

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	< 4.40E+02	< 1.79E-04	< 2.74E-08	< 6.72E-02	< 6.72E-02	< 9.26E-08	> 7.03E+00
2*	2.94E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.00E+00	< 4.00E+02	< 2.05E-05	< 3.13E-09	< 6.11E-02	< 1.28E-01	< 3.38E-08	> 7.47E+00
4*	2.00E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.00E+00	< 4.14E+02	< 2.77E-05	< 4.23E-09	< 6.33E-02	< 1.92E-01	< 2.57E-07	> 6.59E+00
6*	4.00E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.01E+00	< 4.24E+02	< 2.89E-05	< 4.42E-09	< 6.48E-02	< 2.56E-01	< 5.09E-07	> 6.29E+00
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.60E+01	< 4.48E+02	< 1.11E-06	< 1.69E-10	< 6.85E-02	< 3.25E-01	< 5.04E-09	> 8.30E+00
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
=====								
(90 days)		Mean:	< 5.15E-05	< 7.86E-09			< 1.80E-07	> 7.14E+00
		Standard Deviation:	3.23E-05	4.93E-09			9.33E-08	3.52E-01

Co

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	< 5.50E+02	< 2.24E-04	< 7.41E-09	< 1.82E-02	< 1.82E-02	< 6.78E-09	> 8.17E+00
2*	2.94E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.00E+00	< 5.00E+02	< 2.56E-05	< 8.47E-10	< 1.65E-02	< 3.47E-02	< 2.48E-09	> 8.61E+00
4*	2.00E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.00E+00	< 5.18E+02	< 3.46E-05	< 1.15E-09	< 1.71E-02	< 5.19E-02	< 1.88E-08	> 7.73E+00
6*	4.00E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.01E+00	< 5.30E+02	< 3.62E-05	< 1.20E-09	< 1.75E-02	< 6.94E-02	< 3.73E-08	> 7.43E+00
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.60E+01	< 5.60E+02	< 1.38E-06	< 4.58E-11	< 1.85E-02	< 8.79E-02	< 3.69E-10	> 9.43E+00
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
=====								
(90 days)		Mean:	< 6.43E-05	< 2.13E-09			< 1.32E-08	> 8.27E+00
		Standard Deviation:	4.04E-05	1.34E-09			6.83E-09	3.52E-01

Cr

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	< 1.10E+02	< 4.48E-05	< 2.78E-10	< 6.84E-04	< 6.84E-04	< 9.59E-12	> 1.10E+01
2*	2.94E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.00E+00	< 1.00E+02	< 5.12E-06	< 3.19E-11	< 6.22E-04	< 1.31E-03	< 3.50E-12	> 1.15E+01
4*	2.00E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.00E+00	< 1.04E+02	< 6.92E-06	< 4.31E-11	< 6.44E-04	< 1.95E-03	< 2.66E-11	> 1.06E+01
6*	4.00E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.01E+00	< 1.06E+02	< 7.24E-06	< 4.50E-11	< 6.59E-04	< 2.61E-03	< 5.27E-11	> 1.03E+01
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.60E+01	< 1.12E+02	< 2.77E-07	< 1.72E-12	< 6.97E-04	< 3.31E-03	< 5.22E-13	> 1.23E+01
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
=====								
(90 days)		Mean:	< 1.29E-05	< 8.00E-11			< 1.86E-11	> 1.11E+01
		Standard Deviation:	8.07E-06	5.02E-11			9.65E-12	3.52E-01

TABLE G-10. Radionuclide and stable metal leaching data for Brunswick-1 mixed-bed resin waste-form specimen leached in synthetic seawater with pH 6.4.

Mn-54

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	< 7.94E-05	< 4.62E-11	< 1.37E-11	< 2.36E-05	< 2.36E-05	< 5.32E-14	> 1.33E+01
2*	2.94E-01	< 8.54E-05	< 2.04E-11	< 6.04E-12	< 2.53E-05	< 4.89E-05	< 8.42E-14	> 1.31E+01
3*	1.00E+00	< 1.15E-04	< 8.05E-12	< 2.39E-12	< 3.40E-05	< 8.30E-05	< 4.50E-14	> 1.33E+01
4*	2.00E+00	< 9.71E-05	< 4.82E-12	< 1.43E-12	< 2.88E-05	< 1.12E-04	< 3.96E-14	> 1.34E+01
5*	3.00E+00	< 8.56E-05	< 4.25E-12	< 1.26E-12	< 2.54E-05	< 1.37E-04	< 5.23E-14	> 1.33E+01
6*	4.00E+00	< 1.52E-04	< 7.54E-12	< 2.24E-12	< 4.51E-05	< 1.82E-04	< 2.31E-13	> 1.26E+01
7*	5.02E+00	< 8.63E-05	< 4.23E-12	< 1.25E-12	< 2.56E-05	< 2.08E-04	< 9.37E-14	> 1.30E+01
8*	1.81E+01	< 1.49E-04	< 5.67E-13	< 1.68E-13	< 4.43E-05	< 2.52E-04	< 3.96E-15	> 1.44E+01
9*	4.60E+01	< 1.09E-04	< 1.94E-13	< 5.77E-14	< 3.24E-05	< 2.85E-04	< 1.34E-15	> 1.49E+01
10*	9.10E+01	< 1.25E-04	< 1.38E-13	< 4.10E-14	< 3.72E-05	< 3.22E-04	< 1.49E-15	> 1.48E+01
11*	1.70E+02	< 1.05E-04	< 6.56E-14	< 1.95E-14	< 3.10E-05	< 3.53E-04	< 6.40E-16	> 1.52E+01
12*	2.01E+02	< 7.43E-05	< 1.20E-13	< 3.56E-14	< 2.20E-05	< 3.75E-04	< 3.11E-15	> 1.45E+01
=====								
		Mean:	< 8.05E-12	< 2.39E-12				
		Standard Deviation:	3.85E-12	1.14E-12				
							< 5.08E-14	> 1.38E+01
							1.90E-14	2.52E-01

Co-58

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	< 1.98E-03	< 1.15E-09	< 2.58E-09	< 4.44E-03	< 4.44E-03	< 1.89E-09	> 8.72E+00
2*	2.94E-01	< 3.10E-03	< 7.39E-10	< 1.66E-09	< 6.97E-03	< 1.14E-02	< 6.36E-09	> 8.20E+00
3*	1.00E+00	< 5.77E-03	< 4.05E-10	< 9.10E-10	< 1.30E-02	< 2.44E-02	< 6.53E-09	> 8.19E+00
4*	2.00E+00	< 4.31E-03	< 2.14E-10	< 4.82E-10	< 9.70E-03	< 3.41E-02	< 4.49E-09	> 8.35E+00
5*	3.00E+00	< 3.77E-03	< 1.87E-10	< 4.21E-10	< 8.48E-03	< 4.26E-02	< 5.82E-09	> 8.23E+00
6*	4.00E+00	< 4.62E-03	< 2.29E-10	< 5.15E-10	< 1.04E-02	< 5.29E-02	< 1.22E-08	> 7.91E+00
7*	5.02E+00	< 3.61E-03	< 1.77E-10	< 3.97E-10	< 8.12E-03	< 6.11E-02	< 9.42E-09	> 8.03E+00
8*	1.81E+01	< 5.05E-03	< 1.92E-11	< 4.32E-11	< 1.14E-02	< 7.24E-02	< 2.60E-10	> 9.58E+00
9*	4.60E+01	< 3.72E-03	< 6.62E-12	< 1.49E-11	< 8.36E-03	< 8.08E-02	< 8.94E-11	> 1.00E+01
10*	9.10E+01	< 5.41E-03	< 5.96E-12	< 1.34E-11	< 1.22E-02	< 9.29E-02	< 1.59E-10	> 9.80E+00
11*	1.70E+02	< 3.37E-03	< 2.11E-12	< 4.75E-12	< 7.58E-03	< 1.01E-01	< 3.82E-11	> 1.04E+01
12*	2.01E+02	< 3.50E-03	< 5.65E-12	< 1.27E-11	< 7.86E-03	< 1.08E-01	< 3.96E-10	> 9.40E+00
=====								
		Mean:	< 2.62E-10	< 5.88E-10				
		Standard Deviation:	1.02E-10	2.29E-10				
							< 3.97E-09	> 8.91E+00
							1.20E-09	2.56E-01

Co-60

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	1.39E-04	8.08E-11	3.89E-12	6.69E-06	6.69E-06	4.28E-15	1.44E+01
2*	2.94E-01	2.89E-04	6.89E-11	3.32E-12	1.39E-05	2.06E-05	2.54E-14	1.36E+01
3*	1.00E+00	3.28E-04	2.30E-11	1.11E-12	1.58E-05	3.64E-05	9.68E-15	1.40E+01
4*	2.00E+00	1.29E-04	6.42E-12	3.09E-13	6.22E-06	4.26E-05	1.84E-15	1.47E+01
5*	3.00E+00	1.43E-04	7.09E-12	3.41E-13	6.87E-06	4.95E-05	3.83E-15	1.44E+01
6*	4.00E+00	9.74E-05	4.83E-12	2.32E-13	4.69E-06	5.42E-05	2.49E-15	1.46E+01
7*	5.02E+00	3.07E-04	1.50E-11	7.24E-13	1.48E-05	6.90E-05	3.13E-14	1.35E+01
8*	1.81E+01	1.12E-03	4.26E-12	2.05E-13	5.39E-05	1.23E-04	5.86E-15	1.42E+01
9*	4.60E+01	9.43E-04	1.68E-12	8.08E-14	4.54E-05	1.68E-04	2.64E-15	1.46E+01
10*	9.10E+01	5.90E-03	6.50E-12	3.13E-13	2.84E-04	4.52E-04	8.65E-14	1.31E+01
11*	1.70E+02	5.74E-04	3.60E-13	1.73E-14	2.76E-05	4.80E-04	5.08E-16	1.53E+01
12*	2.01E+02	1.91E-04	3.09E-13	1.49E-14	9.20E-06	4.89E-04	5.42E-16	1.53E+01
=====								
		Mean:	1.83E-11	8.79E-13				
		Standard Deviation:	7.88E-12	3.79E-13				
							1.46E-14	1.43E+01
							7.15E-15	1.95E-01

TABLE G-10. Radionuclide and stable metal leaching data for Brunswick-1 mixed-bed resin waste-form specimen leached in synthetic seawater with pH 6.4. (continued)

Zn-65

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	< 7.94E-05	< 4.62E-11	< 1.53E-10	< 2.63E-04	< 2.63E-04	< 6.64E-12	> 1.12E+01
2*	2.94E-01	< 2.87E-04	< 6.83E-11	< 2.26E-10	< 9.50E-04	< 1.21E-03	< 1.18E-10	> 9.93E+00
3*	1.00E+00	< 2.04E-04	< 1.43E-11	< 4.75E-11	< 6.77E-04	< 1.89E-03	< 1.78E-11	> 1.08E+01
4*	2.00E+00	< 2.10E-04	< 1.04E-11	< 3.46E-11	< 6.97E-04	< 2.59E-03	< 2.32E-11	> 1.06E+01
5*	3.00E+00	< 2.25E-04	< 1.12E-11	< 3.71E-11	< 7.47E-04	< 3.33E-03	< 4.52E-11	> 1.03E+01
6*	4.00E+00	< 4.41E-04	< 2.19E-11	< 7.25E-11	< 1.46E-03	< 4.80E-03	< 2.43E-10	> 9.61E+00
7*	5.02E+00	< 1.94E-04	< 9.48E-12	< 3.14E-11	< 6.42E-04	< 5.44E-03	< 5.89E-11	> 1.02E+01
8*	1.81E+01	< 3.47E-04	< 1.32E-12	< 4.36E-12	< 1.15E-03	< 6.59E-03	< 2.66E-12	> 1.16E+01
9*	4.60E+01	< 1.93E-04	< 3.44E-13	< 1.14E-12	< 6.40E-04	< 7.23E-03	< 5.24E-13	> 1.23E+01
10*	9.10E+01	< 2.36E-04	< 2.60E-13	< 8.63E-13	< 7.82E-04	< 8.01E-03	< 6.58E-13	> 1.22E+01
11*	1.70E+02	< 1.89E-04	< 1.18E-13	< 3.93E-13	< 6.26E-04	< 8.64E-03	< 2.61E-13	> 1.26E+01
12*	2.01E+02	< 1.15E-04	< 1.85E-13	< 6.14E-13	< 3.80E-04	< 9.02E-03	< 9.26E-13	> 1.20E+01
Mean:								< 4.31E-11 > 1.11E+01
Standard Deviation:								2.08E-11 2.90E-01

Sb-125

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	1.03E-04	5.99E-11	7.50E-11	1.29E-04	1.29E-04	1.59E-12	1.18E+01
2*	2.94E-01	1.62E-04	3.86E-11	4.83E-11	2.03E-04	3.32E-04	5.38E-12	1.13E+01
3*	1.00E+00	2.00E-04	1.40E-11	1.76E-11	2.51E-04	5.82E-04	2.44E-12	1.16E+01
4*	2.00E+00	< 1.66E-04	< 8.25E-12	< 1.03E-11	< 2.08E-04	< 7.90E-04	< 2.06E-12	> 1.17E+01
5*	3.00E+00	< 1.79E-04	< 8.87E-12	< 1.11E-11	< 2.24E-04	< 1.01E-03	< 4.05E-12	> 1.14E+01
6*	4.00E+00	< 1.97E-04	< 9.76E-12	< 1.22E-11	< 2.46E-04	< 1.26E-03	< 6.89E-12	> 1.12E+01
7*	5.02E+00	< 2.13E-04	< 1.04E-11	< 1.31E-11	< 2.67E-04	< 1.53E-03	< 1.02E-11	> 1.10E+01
8*	1.81E+01	3.45E-04	1.31E-12	1.64E-12	4.32E-04	< 1.96E-03	3.76E-13	1.24E+01
9*	4.60E+01	2.55E-04	4.53E-13	5.67E-13	3.19E-04	< 2.28E-03	1.30E-13	1.29E+01
10*	9.10E+01	3.07E-04	3.39E-13	4.24E-13	3.84E-04	< 2.66E-03	1.59E-13	1.28E+01
11*	1.70E+02	4.31E-04	2.71E-13	3.39E-13	5.40E-04	< 3.20E-03	1.94E-13	1.27E+01
12*	2.01E+02	4.09E-04	6.61E-13	8.28E-13	5.13E-04	< 3.71E-03	1.68E-12	1.18E+01
Mean:								< 2.93E-12 > 1.19E+01
Standard Deviation:								9.09E-13 1.92E-01

Cs-134

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	7.00E-05	4.07E-11	3.68E-09	6.32E-03	6.32E-03	3.83E-09	8.42E+00
2*	2.94E-01	9.14E-05	2.18E-11	1.97E-09	8.26E-03	1.46E-02	8.94E-09	8.05E+00
3*	1.00E+00	1.26E-04	8.86E-12	8.01E-10	1.14E-02	2.60E-02	5.06E-09	8.30E+00
4*	2.00E+00	1.31E-04	6.49E-12	5.87E-10	1.18E-02	3.78E-02	6.66E-09	8.18E+00
5*	3.00E+00	1.28E-04	6.36E-12	5.75E-10	1.16E-02	4.94E-02	1.08E-08	7.97E+00
6*	4.00E+00	< 7.37E-05	< 3.65E-12	< 3.30E-10	< 6.66E-03	< 5.60E-02	< 5.03E-09	> 8.30E+00
7*	5.02E+00	6.04E-05	2.95E-12	2.67E-10	5.45E-03	< 6.15E-02	4.25E-09	8.37E+00
8*	1.81E+01	2.76E-04	1.05E-12	9.46E-11	2.49E-02	< 8.64E-02	1.25E-09	8.90E+00
9*	4.60E+01	2.23E-04	3.98E-13	3.60E-11	2.02E-02	< 1.07E-01	5.22E-10	9.28E+00
10*	9.10E+01	1.71E-04	1.89E-13	1.71E-11	1.55E-02	< 1.22E-01	2.57E-10	9.59E+00
11*	1.70E+02	< 7.50E-05	< 4.70E-14	< 4.25E-12	< 6.78E-03	< 1.29E-01	< 3.05E-11	> 1.05E+01
12*	2.01E+02	< 4.04E-05	< 6.53E-14	< 5.90E-12	< 3.65E-03	< 1.32E-01	< 8.54E-11	> 1.01E+01
Mean:								< 3.90E-09 > 8.83E+00
Standard Deviation:								1.05E-09 2.45E-01

TABLE G-10. Radionuclide and stable metal leaching data for Brunswick-1 mixed-bed resin waste-form specimen leached in synthetic seawater with pH 6.4. (continued)

Cs-137

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	6.07E-04	3.53E-10	6.12E-09	1.05E-02	1.05E-02	1.06E-08	7.98E+00
2*	2.94E-01	9.86E-04	2.35E-10	4.07E-09	1.71E-02	2.76E-02	3.82E-08	7.42E+00
3*	1.00E+00	1.44E-03	1.01E-10	1.75E-09	2.49E-02	5.25E-02	2.41E-08	7.62E+00
4*	2.00E+00	1.12E-03	5.57E-11	9.66E-10	1.94E-02	7.20E-02	1.80E-08	7.74E+00
5*	3.00E+00	8.70E-04	4.32E-11	7.49E-10	1.51E-02	8.70E-02	1.84E-08	7.73E+00
6*	4.00E+00	8.17E-04	4.05E-11	7.01E-10	1.42E-02	1.01E-01	2.27E-08	7.64E+00
7*	5.02E+00	7.70E-04	3.77E-11	6.53E-10	1.33E-02	1.15E-01	2.54E-08	7.59E+00
8*	1.81E+01	4.55E-03	1.73E-11	2.99E-10	7.88E-02	1.93E-01	1.25E-08	7.90E+00
9*	4.60E+01	2.47E-03	4.41E-12	7.63E-11	4.29E-02	2.36E-01	1.61E-08	7.79E+00
10*	9.10E+01	1.29E-03	1.42E-12	2.47E-11	2.24E-02	2.59E-01	1.03E-08	7.99E+00
11*	1.70E+02	5.52E-04	3.46E-13	6.00E-12	9.57E-03	2.68E-01	5.90E-09	8.23E+00
12*	2.01E+02	2.41E-04	3.89E-13	6.74E-12	4.17E-03	2.72E-01	5.17E-09	8.29E+00
Mean:			7.42E-11	1.28E-09			1.73E-08	7.83E+00
Standard Deviation:			3.17E-11	5.49E-10			2.72E-09	7.50E-02

Pu-241

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.94E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.00E+00	< 2.95E-05	< 2.07E-12	< 6.57E-12	< 9.36E-05	NA	< 3.40E-13	> 1.25E+01
4*	2.00E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.00E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.00E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.02E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.60E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
Mean:			NA	NA			NA	NA
Standard Deviation:			NA	NA			NA	NA

Fe

SAMPLE NUMBER	TOTAL TIME (days)	TOTAL LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	< 7.28E+02	< 4.23E-04	< 4.00E-09	< 6.87E-03	< 6.87E-03	< 4.52E-09	> 8.34E+00
2*	2.94E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.00E+00	< 7.91E+02	< 5.55E-05	< 5.24E-10	< 7.47E-03	NA	< 2.17E-09	> 8.66E+00
4*	2.00E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.00E+00	1.70E+02	8.45E-06	7.98E-11	1.61E-03	NA	2.09E-10	9.68E+00
6*	4.00E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.02E+00	< 7.95E+02	< 3.89E-05	< 3.67E-10	< 7.51E-03	NA	< 8.05E-09	> 8.09E+00
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.60E+01	< 7.88E+02	< 1.40E-06	< 1.32E-11	< 7.44E-03	NA	< 7.08E-11	> 1.01E+01
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
(90 days)		Mean:	< 1.05E-04	< 9.96E-10			< 3.00E-09	> 8.99E+00
		Standard Deviation:	8.00E-05	7.56E-10			1.50E-09	3.97E-01

TABLE G-10. Radionuclide and stable metal leaching data for Brunswick-1 mixed-bed resin waste-form specimen leached in synthetic seawater with pH 6.4. (continued)

Ni

SAMPLE NUMBER	TOTAL TIME (days)	TOTAL LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	< 3.88E+02	< 2.26E-04	< 2.28E-08	< 3.92E-02	< 3.92E-02	< 1.47E-07	> 6.83E+00
2*	2.94E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.00E+00	< 4.22E+02	< 2.96E-05	< 2.99E-09	< 4.26E-02	NA	< 7.06E-08	> 7.15E+00
4*	2.00E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.00E+00	< 4.36E+02	< 2.17E-05	< 2.19E-09	< 4.41E-02	NA	< 1.57E-07	> 6.80E+00
6*	4.00E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.02E+00	< 4.24E+02	< 2.07E-05	< 2.10E-09	< 4.28E-02	NA	< 2.62E-07	> 6.58E+00
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.60E+01	< 4.20E+02	< 7.48E-07	< 7.56E-11	< 4.24E-02	NA	< 2.31E-09	> 8.64E+00
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
(90 days)		Mean:	< 5.97E-05	< 6.03E-09			< 1.28E-07	> 7.20E+00
Standard Deviation:			4.18E-05	4.22E-09			4.38E-08	3.70E-01

Co

SAMPLE NUMBER	TOTAL TIME (days)	TOTAL LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	< 4.85E+02	< 2.82E-04	< 6.17E-09	< 1.06E-02	< 1.06E-02	< 1.08E-08	> 7.97E+00
2*	2.94E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.00E+00	< 5.28E+02	< 3.70E-05	< 8.09E-10	< 1.15E-02	NA	< 5.17E-09	> 8.29E+00
4*	2.00E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.00E+00	< 5.45E+02	< 2.71E-05	< 5.92E-10	< 1.19E-02	NA	< 1.15E-08	> 7.94E+00
6*	4.00E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.02E+00	< 5.30E+02	< 2.59E-05	< 5.67E-10	< 1.16E-02	NA	< 1.92E-08	> 7.72E+00
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.60E+01	< 5.25E+02	< 9.35E-07	< 2.05E-11	< 1.15E-02	NA	< 1.69E-10	> 9.77E+00
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
(90 days)		Mean:	< 7.46E-05	< 1.63E-09			< 9.37E-09	> 8.34E+00
Standard Deviation:			5.22E-05	1.14E-09			3.21E-09	3.70E-01

Cr

SAMPLE NUMBER	TOTAL TIME (days)	TOTAL LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	2.87E+02	1.67E-04	6.87E-10	1.18E-03	1.18E-03	1.33E-10	9.87E+00
2*	2.94E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.00E+00	5.36E+02	3.76E-05	1.55E-10	2.20E-03	NA	1.88E-10	9.72E+00
4*	2.00E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.00E+00	3.18E+02	1.58E-05	6.50E-11	1.31E-03	NA	1.39E-10	9.86E+00
6*	4.00E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.02E+00	4.30E+02	2.11E-05	8.66E-11	1.77E-03	NA	4.47E-10	9.35E+00
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.60E+01	2.37E+03	4.23E-06	1.74E-11	9.76E-03	NA	1.22E-10	9.91E+00
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
(90 days)		Mean:	4.91E-05	2.02E-10			2.06E-10	9.74E+00
Standard Deviation:			2.99E-05	1.23E-10			6.14E-11	1.04E-01

APPENDIX H

RADIONUCLIDE AND STABLE METAL LEACHING DATA FOR FITZPATRICK WASTE-FORM SPECIMENS

APPENDIX H

RADIONUCLIDE AND STABLE METAL LEACHING DATA FOR FITZPATRICK WASTE-FORM SPECIMENS

Radionuclide and stable metal leaching data for seven mixed-bed resin waste-form specimens obtained from James A. FitzPatrick Station are given in Tables H-1 through H-7. Appendix H contains data derived from the data in Appendix J.

TABLE H-1. Radionuclide and stable metal leaching data for James A. FitzPatrick mixed-bed resin waste-form specimen leached in deionized water

Mn-54

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	2.85E-03	2.18E-09	1.21E-11	1.58E-05	1.58E-05	2.40E-14	1.36E+01
2*	2.93E-01	1.78E-02	5.54E-09	3.08E-11	9.90E-05	1.15E-04	1.27E-12	1.19E+01
3*	1.00E+00	4.34E-03	3.96E-10	2.20E-12	2.41E-05	1.39E-04	2.23E-14	1.37E+01
4*	2.00E+00	3.46E-03	2.24E-10	1.25E-12	1.92E-05	1.58E-04	1.75E-14	1.38E+01
5*	3.00E+00	5.74E-03	3.72E-10	2.06E-12	3.19E-05	1.90E-04	8.17E-14	1.31E+01
6*	4.00E+00	7.59E-03	4.93E-10	2.74E-12	4.22E-05	2.32E-04	2.02E-13	1.27E+01
7*	5.00E+00	1.41E-02	9.14E-10	5.07E-12	7.85E-05	3.11E-04	8.93E-13	1.20E+01
8*	1.79E+01	2.02E-02	1.01E-10	5.64E-13	1.12E-04	4.23E-04	2.57E-14	1.36E+01
9*	4.61E+01	1.92E-02	4.41E-11	2.45E-13	1.07E-04	5.30E-04	1.41E-14	1.39E+01
10*	9.80E+01	4.86E-03	6.07E-12	3.37E-14	2.70E-05	5.57E-04	6.12E-16	1.52E+01
11*	1.43E+02	8.99E-04	1.29E-12	7.19E-15	4.99E-06	5.62E-04	4.77E-17	1.63E+01
12*	1.71E+02	1.01E-03	2.34E-12	1.30E-14	5.62E-06	5.67E-04	2.05E-16	1.57E+01
13*	2.47E+02	3.77E-03	3.21E-12	1.78E-14	2.09E-05	5.88E-04	5.09E-16	1.53E+01
Mean: < 7.91E-10 < 4.39E-12 < 1.96E-13 > 1.39E+01								
Standard Deviation: 4.30E-10 2.39E-12 1.12E-13 3.80E-01								

Fe-55

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.93E-01	8.20E-03	2.55E-09	2.60E-10	8.37E-04	NA	9.08E-11	1.00E+01
3*	1.00E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.00E+00	6.95E-03	4.50E-10	4.60E-11	7.09E-04	NA	2.38E-11	1.06E+01
5*	3.00E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.00E+00	5.69E-03	3.69E-10	3.77E-11	5.81E-04	NA	3.82E-11	1.04E+01
7*	5.00E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	4.42E-03	2.22E-11	2.26E-12	4.52E-04	NA	4.15E-13	1.24E+01
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.80E+01	6.52E-04	8.15E-13	8.32E-14	6.66E-05	NA	3.72E-15	1.44E+01
(90 days) Mean: 6.79E-10 6.93E-11 3.07E-11 1.16E+01								
Standard Deviation: 4.77E-10 4.87E-11 1.67E-11 8.18E-01								

Co-58

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	1.40E-02	1.07E-08	5.73E-11	7.49E-05	7.49E-05	5.38E-13	1.23E+01
2*	2.93E-01	7.30E-02	2.27E-08	1.21E-10	3.90E-04	4.65E-04	1.97E-11	1.07E+01
3*	1.00E+00	1.45E-01	1.32E-08	7.04E-11	7.72E-04	1.24E-03	2.28E-11	1.06E+01
4*	2.00E+00	1.56E-01	1.01E-08	5.41E-11	8.35E-04	2.07E-03	3.30E-11	1.05E+01
5*	3.00E+00	1.34E-01	8.67E-09	4.63E-11	7.15E-04	2.79E-03	4.11E-11	1.04E+01
6*	4.00E+00	1.21E-01	7.85E-09	4.19E-11	6.46E-04	3.43E-03	4.73E-11	1.03E+01
7*	5.00E+00	1.30E-01	8.42E-09	4.50E-11	6.96E-04	4.13E-03	7.02E-11	1.02E+01
8*	1.79E+01	4.58E-01	2.30E-09	1.23E-11	2.45E-03	6.57E-03	1.22E-11	1.09E+01
9*	4.61E+01	5.20E-01	1.20E-09	6.39E-12	2.78E-03	9.35E-03	9.58E-12	1.10E+01
10*	9.80E+01	5.16E-01	6.44E-10	3.44E-12	2.75E-03	1.21E-02	6.36E-12	1.12E+01
11*	1.43E+02	4.28E-01	6.16E-10	3.29E-12	2.28E-03	1.44E-02	9.98E-12	1.10E+01
12*	1.71E+02	3.83E-01	8.86E-10	4.73E-12	2.05E-03	1.64E-02	2.71E-11	1.06E+01
13*	2.47E+02	5.86E-01	4.99E-10	2.67E-12	3.13E-03	1.96E-02	1.14E-11	1.09E+01
Mean: 6.76E-09 3.61E-11 2.39E-11 1.08E+01								
Standard Deviation: 1.84E-09 9.84E-12 5.46E-12 1.48E-01								

TABLE H-1. Radionuclide and stable metal leaching data for James A. FitzPatrick mixed-bed resin waste-form specimen leached in deionized water. (continued)

Co-60

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	7.49E-02	5.73E-08	8.10E-11	1.06E-04	1.06E-04	1.07E-12	1.20E+01
2*	2.93E-01	3.95E-01	1.23E-07	1.74E-10	5.59E-04	6.65E-04	4.05E-11	1.04E+01
3*	1.00E+00	7.78E-01	7.11E-08	1.00E-10	1.10E-03	1.77E-03	4.64E-11	1.03E+01
4*	2.00E+00	8.50E-01	5.50E-08	7.78E-11	1.20E-03	2.97E-03	6.84E-11	1.02E+01
5*	3.00E+00	7.33E-01	4.75E-08	6.71E-11	1.04E-03	4.00E-03	8.62E-11	1.01E+01
6*	4.00E+00	6.52E-01	4.23E-08	5.98E-11	9.21E-04	4.92E-03	9.62E-11	1.00E+01
7*	5.00E+00	7.05E-01	4.56E-08	6.44E-11	9.97E-04	5.92E-03	1.44E-10	9.84E+00
8*	1.79E+01	2.50E+00	1.26E-08	1.77E-11	3.54E-03	9.46E-03	2.55E-11	1.06E+01
9*	4.61E+01	2.84E+00	6.53E-09	9.24E-12	4.01E-03	1.35E-02	2.00E-11	1.07E+01
10*	9.80E+01	2.81E+00	3.50E-09	4.95E-12	3.97E-03	1.74E-02	1.32E-11	1.09E+01
11*	1.43E+02	2.35E+00	3.38E-09	4.78E-12	3.32E-03	2.08E-02	2.11E-11	1.07E+01
12*	1.71E+02	2.11E+00	4.88E-09	6.91E-12	2.98E-03	2.37E-02	5.78E-11	1.02E+01
13*	2.47E+02	2.81E+00	2.39E-09	3.38E-12	3.97E-03	2.77E-02	1.83E-11	1.07E+01
Mean:			3.65E-08	5.17E-11			4.91E-11	1.05E+01
Standard Deviation:			9.97E-09	1.41E-11			1.13E-11	1.50E-01

Ni-63

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	1.43E-02	1.09E-08	4.51E-10	5.90E-04	5.90E-04	3.33E-11	1.05E+01
2*	2.93E-01	8.38E-02	2.61E-08	1.08E-09	3.46E-03	4.05E-03	1.55E-09	8.81E+00
3*	1.00E+00	3.67E-01	3.35E-08	1.39E-09	1.52E-02	1.92E-02	8.82E-09	8.05E+00
4*	2.00E+00	2.92E-01	1.89E-08	7.81E-10	1.20E-02	3.13E-02	6.88E-09	8.16E+00
5*	3.00E+00	2.88E-01	1.87E-08	7.71E-10	1.19E-02	4.32E-02	1.14E-08	7.94E+00
6*	4.00E+00	1.69E-01	1.09E-08	4.52E-10	6.97E-03	5.02E-02	5.51E-09	8.26E+00
7*	5.00E+00	1.72E-01	1.11E-08	4.59E-10	7.10E-03	5.73E-02	7.30E-09	8.14E+00
8*	1.79E+01	4.27E-01	2.14E-09	8.84E-11	1.76E-02	7.49E-02	6.33E-10	9.20E+00
9*	4.61E+01	2.62E-01	6.03E-10	2.49E-11	1.08E-02	8.57E-02	1.46E-10	9.84E+00
10*	9.80E+01	1.43E-01	1.78E-10	7.35E-12	5.89E-03	9.16E-02	2.91E-11	1.05E+01
(90 days) Mean:			1.33E-08	5.50E-10			4.23E-09	8.94E+00
Standard Deviation:			3.50E-09	1.45E-10			1.34E-09	3.21E-01

Zn-65

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	5.24E-04	4.00E-10	9.52E-12	1.24E-05	1.24E-05	1.48E-14	1.38E+01
2*	2.93E-01	6.71E-03	2.09E-09	4.96E-11	1.60E-04	1.72E-04	3.30E-12	1.15E+01
3*	1.00E+00	2.19E-03	1.99E-10	4.74E-12	5.20E-05	2.24E-04	1.03E-13	1.30E+01
4*	2.00E+00	6.29E-03	4.08E-10	9.69E-12	1.50E-04	3.74E-04	1.06E-12	1.20E+01
5*	3.00E+00	2.76E-03	1.79E-10	4.25E-12	6.57E-05	4.39E-04	3.47E-13	1.25E+01
6*	4.00E+00	5.53E-03	3.59E-10	8.53E-12	1.32E-04	5.71E-04	1.96E-12	1.17E+01
7*	5.00E+00	6.94E-03	4.48E-10	1.07E-11	1.65E-04	7.36E-04	3.94E-12	1.14E+01
8*	1.79E+01	1.83E-02	9.18E-11	2.18E-12	4.36E-04	1.17E-03	3.86E-13	1.24E+01
9*	4.61E+01	2.33E-02	5.36E-11	1.27E-12	5.53E-04	1.72E-03	3.81E-13	1.24E+01
10*	9.80E+01	2.23E-02	2.79E-11	6.63E-13	5.31E-04	2.26E-03	2.37E-13	1.26E+01
11*	1.43E+02	2.06E-02	2.97E-11	7.06E-13	4.91E-04	2.75E-03	4.61E-13	1.23E+01
12*	1.71E+02	6.72E-03	1.56E-11	3.70E-13	1.60E-04	2.91E-03	1.66E-13	1.28E+01
13*	2.47E+02	1.16E-02	9.88E-12	2.35E-13	2.75E-04	3.18E-03	8.84E-14	1.31E+01
Mean:			3.32E-10	7.88E-12			9.57E-13	1.24E+01
Standard Deviation:			1.53E-10	3.65E-12			3.60E-13	1.88E-01

TABLE H-1. Radionuclide and stable metal leaching data for James A. FitzPatrick mixed-bed resin waste-form specimen leached in deionized water. (continued)

Sb-125

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	< 2.23E-04	< 1.70E-10	< 1.11E-10	< 1.45E-04	< 1.45E-04	< 2.00E-12	> 1.17E+01
2*	2.93E-01	< 5.42E-04	< 1.69E-10	< 1.09E-10	< 3.52E-04	< 4.96E-04	< 1.60E-11	> 1.08E+01
3*	1.00E+00	< 1.28E-03	< 1.17E-10	< 7.56E-11	< 8.28E-04	< 1.32E-03	< 2.63E-11	> 1.06E+01
4*	2.00E+00	9.56E-04	6.19E-11	4.02E-11	6.20E-04	< 1.94E-03	1.82E-11	1.07E+01
5*	3.00E+00	< 1.20E-03	< 7.78E-11	< 5.05E-11	< 7.80E-04	< 2.72E-03	< 4.88E-11	> 1.03E+01
6*	4.00E+00	< 1.08E-03	< 7.01E-11	< 4.55E-11	< 7.01E-04	< 3.43E-03	< 5.57E-11	> 1.03E+01
7*	5.00E+00	1.74E-03	1.12E-10	7.30E-11	1.13E-03	< 4.56E-03	1.85E-10	9.73E+00
8*	1.79E+01	1.31E-03	6.56E-12	4.26E-12	8.50E-04	< 5.40E-03	1.47E-12	1.18E+01
9*	4.61E+01	< 1.55E-03	< 3.56E-12	< 2.31E-12	< 1.00E-03	< 6.41E-03	< 1.26E-12	> 1.19E+01
10*	9.80E+01	< 1.92E-03	< 2.40E-12	< 1.56E-12	< 1.25E-03	< 7.66E-03	< 1.31E-12	> 1.19E+01
11*	1.43E+02	1.03E-03	1.49E-12	9.64E-13	6.70E-04	< 8.33E-03	8.58E-13	1.21E+01
12*	1.71E+02	< 1.28E-03	< 2.97E-12	< 1.93E-12	< 8.33E-04	< 9.16E-03	< 4.50E-12	> 1.13E+01
13*	2.47E+02	< 2.33E-03	< 1.99E-12	< 1.29E-12	< 1.51E-03	< 1.07E-02	< 2.66E-12	> 1.16E+01
=====								
		Mean:		< 6.13E-11	< 3.98E-11			
		Standard Deviation:		1.79E-11	1.16E-11			
						< 2.80E-11	> 1.11E+01	
						1.40E-11	2.13E-01	

Cs-134

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	1.57E-02	1.20E-08	8.70E-09	1.14E-02	1.14E-02	1.24E-08	7.91E+00
2*	2.93E-01	8.65E-02	2.69E-08	1.94E-08	6.25E-02	7.39E-02	5.06E-07	6.30E+00
3*	1.00E+00	1.77E-01	1.61E-08	1.17E-08	1.28E-01	2.02E-01	3.67E-07	6.44E+00
4*	2.00E+00	1.58E-01	1.03E-08	7.42E-09	1.14E-01	3.16E-01	4.87E-07	6.31E+00
5*	3.00E+00	1.12E-01	7.25E-09	5.24E-09	8.09E-02	3.97E-01	5.48E-07	6.26E+00
6*	4.00E+00	7.91E-02	5.13E-09	3.71E-09	5.72E-02	4.54E-01	5.64E-07	6.25E+00
7*	5.00E+00	6.62E-02	4.27E-09	3.09E-09	4.78E-02	5.02E-01	5.77E-07	6.24E+00
8*	1.79E+01	1.55E-01	7.78E-10	5.62E-10	1.12E-01	6.14E-01	2.71E-07	6.57E+00
9*	4.61E+01	1.04E-01	2.40E-10	1.73E-10	7.53E-02	6.89E-01	1.45E-07	6.84E+00
10*	9.80E+01	5.00E-02	6.25E-11	4.51E-11	3.62E-02	7.26E-01	7.99E-08	7.10E+00
11*	1.43E+02	2.20E-02	3.17E-11	2.29E-11	1.59E-02	7.41E-01	5.82E-08	7.24E+00
12*	1.71E+02	1.05E-02	2.42E-11	1.75E-11	7.56E-03	7.49E-01	5.04E-08	7.30E+00
13*	2.47E+02	6.40E-03	5.46E-12	3.94E-12	4.62E-03	7.54E-01	3.57E-08	7.45E+00
=====								
		Mean:		6.40E-09	4.62E-09			
		Standard Deviation:		2.27E-09	1.64E-09			
						2.85E-07	6.78E+00	
						6.37E-08	1.55E-01	

TABLE H-1. Radionuclide and stable metal leaching data for James A. FitzPatrick mixed-bed resin waste-form specimen leached in deionized water. (continued)

Cs-137

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	2.82E-02	2.16E-08	7.64E-09	1.00E-02	1.00E-02	9.57E-09	8.02E+00
2*	2.93E-01	1.56E-01	4.84E-08	1.72E-08	5.52E-02	6.51E-02	3.94E-07	6.40E+00
3*	1.00E+00	3.16E-01	2.88E-08	1.02E-08	1.12E-01	1.77E-01	4.79E-07	6.32E+00
4*	2.00E+00	2.94E-01	1.91E-08	6.75E-09	1.04E-01	2.81E-01	1.23E-07	6.91E+00
5*	3.00E+00	2.03E-01	1.32E-08	4.66E-09	7.20E-02	3.53E-01	1.37E-07	6.86E+00
6*	4.00E+00	1.44E-01	9.31E-09	3.30E-09	5.08E-02	4.04E-01	1.40E-07	6.85E+00
7*	5.00E+00	1.20E-01	7.73E-09	2.74E-09	4.24E-02	4.46E-01	1.42E-07	6.85E+00
8*	1.79E+01	2.79E-01	1.40E-09	4.96E-10	9.89E-02	5.45E-01	6.49E-08	7.19E+00
9*	4.61E+01	1.88E-01	4.32E-10	1.53E-10	6.66E-02	6.12E-01	3.43E-08	7.47E+00
10*	9.80E+01	8.95E-02	1.12E-10	3.96E-11	3.17E-02	6.44E-01	1.85E-08	7.73E+00
11*	1.43E+02	3.85E-02	5.55E-11	1.96E-11	1.36E-02	6.57E-01	1.34E-08	7.87E+00
12*	1.71E+02	1.93E-02	4.47E-11	1.58E-11	6.85E-03	6.64E-01	1.15E-08	7.94E+00
13*	2.47E+02	1.27E-02	1.09E-11	3.85E-12	4.51E-03	6.69E-01	8.18E-09	8.09E+00
Mean:			1.15E-08	4.09E-09			1.21E-07	7.27E+00
Standard Deviation:			4.08E-09	1.44E-09			4.19E-08	1.72E-01

Pu-241

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.93E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.00E+00	7.31E-05	6.67E-12	6.91E-13	7.57E-06	NA	2.20E-15	1.47E+01
4*	2.00E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.00E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.00E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.00E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.80E+01	NA	NA	NA	NA	NA	NA	NA
(90 days) Mean:			NA	NA			NA	NA
Standard Deviation:			NA	NA			NA	NA

Fe

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.93E-01	1.10E+02	3.41E-05	8.37E-11	2.69E-04	NA	9.38E-12	1.10E+01
3*	1.00E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.00E+00	< 1.35E+02	< 8.75E-06	< 2.15E-11	< 3.31E-04	NA	< 5.19E-12	> 1.13E+01
5*	3.00E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.00E+00	< 1.35E+02	< 8.76E-06	< 2.15E-11	< 3.31E-04	NA	< 1.24E-11	> 1.09E+01
7*	5.00E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	5.02E+01	2.52E-07	6.17E-13	1.23E-04	NA	3.09E-14	1.35E+01
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.80E+01	< 1.35E+02	< 1.68E-07	< 4.12E-13	< 3.30E-04	NA	< 9.15E-14	> 1.30E+01
(90 days) Mean:			< 1.04E-05	< 2.55E-11			< 5.43E-12	> 1.20E+01
Standard Deviation:			6.23E-06	1.53E-11			2.47E-12	5.48E-01

TABLE H-1. Radionuclide and stable metal leaching data for James A. FitzPatrick mixed-bed resin waste-form specimen leached in deionized water. (continued)

Ni

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.93E-01	4.12E+01	1.28E-05	7.66E-10	2.46E-03	NA	7.86E-10	9.10E+00
3*	1.00E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.00E+00	1.24E+02	8.04E-06	4.81E-10	7.42E-03	NA	2.61E-09	8.58E+00
5*	3.00E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.00E+00	7.15E+01	4.64E-06	2.77E-10	4.28E-03	NA	2.07E-09	8.68E+00
7*	5.00E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	5.02E+01	2.52E-07	1.51E-11	3.01E-03	NA	1.84E-11	1.07E+01
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.80E+01	1.79E+02	2.23E-07	1.34E-11	1.07E-02	NA	9.62E-11	1.00E+01
=====								
(90 days)		Mean:	5.19E-06	3.11E-10			1.12E-09	9.42E+00
Standard Deviation:			2.40E-06	1.44E-10			5.24E-10	4.14E-01

Co

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.93E-01	< 8.95E+01	< 2.78E-05	< 7.55E-10	< 2.43E-03	NA	< 7.63E-10	> 9.12E+00
3*	1.00E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.00E+00	< 9.00E+01	< 5.83E-06	< 1.58E-10	< 2.44E-03	NA	< 2.82E-10	> 9.55E+00
5*	3.00E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.00E+00	< 9.00E+01	< 5.84E-06	< 1.58E-10	< 2.44E-03	NA	< 6.75E-10	> 9.17E+00
7*	5.00E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	< 8.75E+01	< 4.39E-07	< 1.19E-11	< 2.37E-03	NA	< 1.14E-11	> 1.09E+01
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.80E+01	< 8.98E+01	< 1.12E-07	< 3.04E-12	< 2.43E-03	NA	< 4.97E-12	> 1.13E+01
=====								
(90 days)		Mean:	< 8.01E-06	< 2.17E-10			< 3.47E-10	> 1.00E+01
Standard Deviation:			5.11E-06	1.39E-10			1.60E-10	4.61E-01

Cr

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.93E-01	< 1.79E+01	< 5.57E-06	< 1.98E-10	< 6.37E-04	NA	< 5.26E-11	> 1.03E+01
3*	1.00E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.00E+00	< 1.80E+01	< 1.17E-06	< 4.15E-11	< 6.41E-04	NA	< 1.95E-11	> 1.07E+01
5*	3.00E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.00E+00	< 1.80E+01	< 1.17E-06	< 4.16E-11	< 6.41E-04	NA	< 4.66E-11	> 1.03E+01
7*	5.00E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	< 1.75E+01	< 8.77E-08	< 3.12E-12	< 6.23E-04	NA	< 7.89E-13	> 1.21E+01
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.80E+01	< 1.79E+01	< 2.24E-08	< 7.98E-13	< 6.39E-04	NA	< 3.43E-13	> 1.25E+01
=====								
(90 days)		Mean:	< 1.60E-06	< 5.70E-11			< 2.39E-11	> 1.12E+01
Standard Deviation:			1.02E-06	3.64E-11			1.11E-11	4.61E-01

TABLE H-2. Radionuclide and stable metal leaching data for James A. FitzPatrick mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with pH 10.4.

Mn-54

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	2.95E-03	2.28E-09	1.29E-11	1.68E-05	1.68E-05	2.71E-14	1.36E+01
2*	2.93E-01	5.42E-03	1.68E-09	9.54E-12	3.08E-05	4.75E-05	1.21E-13	1.29E+01
3*	1.00E+00	2.85E-03	2.60E-10	1.48E-12	1.62E-05	6.37E-05	1.00E-14	1.40E+01
4*	2.00E+00	4.33E-03	2.80E-10	1.59E-12	2.45E-05	8.82E-05	2.85E-14	1.35E+01
5*	3.00E+00	3.38E-03	2.19E-10	1.24E-12	1.92E-05	1.07E-04	2.95E-14	1.35E+01
6*	4.00E+00	5.79E-03	3.75E-10	2.13E-12	3.29E-05	1.40E-04	1.22E-13	1.29E+01
7*	5.00E+00	2.95E-03	1.91E-10	1.08E-12	1.67E-05	1.57E-04	4.07E-14	1.34E+01
8*	1.79E+01	1.66E-02	8.31E-11	4.71E-13	9.41E-05	2.51E-04	1.80E-14	1.37E+01
9*	4.61E+01	4.81E-02	1.11E-10	6.29E-13	2.73E-04	5.24E-04	9.28E-14	1.30E+01
10*	9.80E+01	4.60E-03	5.74E-12	3.26E-14	2.61E-05	5.50E-04	5.71E-16	1.52E+01
=====								
(90 days)		Mean:	5.48E-10	3.11E-12			4.91E-14	1.36E+01
		Standard Deviation:	2.45E-10	1.39E-12			1.44E-14	2.16E-01

Fe-55

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.93E-01	5.94E-03	1.84E-09	1.92E-10	6.20E-04	NA	4.92E-11	1.03E+01
3*	1.00E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.00E+00	9.10E-03	5.90E-10	6.15E-11	9.49E-04	NA	4.27E-11	1.04E+01
5*	3.00E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.00E+00	4.55E-03	2.95E-10	3.08E-11	4.75E-04	NA	2.55E-11	1.06E+01
7*	5.00E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	1.08E-02	5.44E-11	5.67E-12	1.13E-03	NA	2.60E-12	1.16E+01
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.80E+01	2.38E-04	2.97E-13	3.09E-14	2.48E-05	NA	5.15E-16	1.53E+01
=====								
(90 days)		Mean:	5.56E-10	5.80E-11			2.40E-11	1.16E+01
		Standard Deviation:	3.38E-10	3.52E-11			1.01E-11	9.43E-01

Co-58

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	1.05E-02	8.06E-09	4.40E-11	5.71E-05	5.71E-05	3.14E-13	1.25E+01
2*	2.93E-01	5.65E-02	1.75E-08	9.55E-11	3.08E-04	3.65E-04	1.22E-11	1.09E+01
3*	1.00E+00	1.32E-01	1.21E-08	6.58E-11	7.20E-04	1.08E-03	1.99E-11	1.07E+01
4*	2.00E+00	1.01E-01	6.55E-09	3.57E-11	5.52E-04	1.64E-03	1.44E-11	1.08E+01
5*	3.00E+00	9.76E-02	6.31E-09	3.44E-11	5.33E-04	2.17E-03	2.27E-11	1.06E+01
6*	4.00E+00	9.99E-02	6.48E-09	3.53E-11	5.45E-04	2.71E-03	3.36E-11	1.05E+01
7*	5.00E+00	8.70E-02	5.64E-09	3.08E-11	4.75E-04	3.19E-03	3.28E-11	1.05E+01
8*	1.79E+01	4.26E-01	2.14E-09	1.17E-11	2.33E-03	5.52E-03	1.10E-11	1.10E+01
9*	4.61E+01	5.04E-01	1.16E-09	6.33E-12	2.75E-03	8.27E-03	9.42E-12	1.10E+01
10*	9.80E+01	5.98E-01	7.47E-10	4.07E-12	3.26E-03	1.15E-02	8.93E-12	1.10E+01
=====								
(90 days)		Mean:	6.66E-09	3.64E-11			1.65E-11	1.10E+01
		Standard Deviation:	1.62E-09	8.83E-12			3.39E-12	1.84E-01

TABLE H-2. Radionuclide and stable metal leaching data for James A. FitzPatrick mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with pH 10.4. (continued)

Co-60

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	5.47E-02	4.22E-08	6.09E-11	7.90E-05	7.90E-05	6.03E-13	1.22E+01
2*	2.93E-01	3.00E-01	9.30E-08	1.34E-10	4.33E-04	5.12E-04	2.41E-11	1.06E+01
3*	1.00E+00	7.03E-01	6.43E-08	9.30E-11	1.02E-03	1.53E-03	3.97E-11	1.04E+01
4*	2.00E+00	5.46E-01	3.54E-08	5.12E-11	7.90E-04	2.32E-03	2.95E-11	1.05E+01
5*	3.00E+00	5.31E-01	3.43E-08	4.95E-11	7.67E-04	3.09E-03	4.70E-11	1.03E+01
6*	4.00E+00	5.40E-01	3.50E-08	5.05E-11	7.80E-04	3.86E-03	6.88E-11	1.02E+01
7*	5.00E+00	4.76E-01	3.08E-08	4.45E-11	6.88E-04	4.55E-03	6.88E-11	1.02E+01
8*	1.79E+01	2.31E+00	1.16E-08	1.67E-11	3.34E-03	7.89E-03	2.27E-11	1.06E+01
9*	4.61E+01	2.74E+00	6.30E-09	9.10E-12	3.95E-03	1.18E-02	1.94E-11	1.07E+01
10*	9.80E+01	3.30E+00	4.12E-09	5.95E-12	4.76E-03	1.66E-02	1.90E-11	1.07E+01
=====								
(90 days)		Mean:	3.57E-08	5.16E-11			3.40E-11	1.06E+01
Standard Deviation:			8.57E-09	1.24E-11			7.01E-12	1.86E-01

Ni-63

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	3.83E-03	2.95E-09	1.25E-10	1.62E-04	1.62E-04	2.53E-12	1.16E+01
2*	2.93E-01	3.22E-01	9.99E-08	4.22E-09	1.36E-02	1.38E-02	2.37E-08	7.62E+00
3*	1.00E+00	2.48E-01	2.27E-08	9.59E-10	1.05E-02	2.43E-02	4.23E-09	8.37E+00
4*	2.00E+00	1.60E-01	1.04E-08	4.38E-10	6.76E-03	3.10E-02	2.17E-09	8.66E+00
5*	3.00E+00	NA	NA	4.83E-10	NA	NA	NA	NA
6*	4.00E+00	1.93E-01	1.25E-08	5.27E-10	8.13E-03	NA	7.49E-09	8.13E+00
7*	5.00E+00	1.39E-01	8.97E-09	3.79E-10	5.85E-03	NA	4.98E-09	8.30E+00
8*	1.79E+01	3.87E-01	1.94E-09	8.19E-11	1.63E-02	NA	5.43E-10	9.26E+00
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.80E+01	2.42E-01	3.02E-10	1.27E-11	1.02E-02	NA	8.73E-11	1.01E+01
=====								
(90 days)		Mean:	2.00E-08	8.42E-10			5.40E-09	9.00E+00
Standard Deviation:			1.17E-08	4.94E-10			2.78E-09	4.55E-01

Zn-65

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	1.25E-03	9.62E-10	2.34E-11	3.03E-05	3.03E-05	8.87E-14	1.31E+01
2*	2.93E-01	6.07E-03	1.88E-09	4.57E-11	1.47E-04	1.78E-04	2.79E-12	1.16E+01
3*	1.00E+00	6.92E-03	6.33E-10	1.54E-11	1.68E-04	3.46E-04	1.09E-12	1.20E+01
4*	2.00E+00	6.86E-03	4.44E-10	1.08E-11	1.67E-04	5.12E-04	1.31E-12	1.19E+01
5*	3.00E+00	6.90E-03	4.46E-10	1.08E-11	1.68E-04	6.80E-04	2.24E-12	1.16E+01
6*	4.00E+00	9.23E-03	5.98E-10	1.45E-11	2.24E-04	9.04E-04	5.69E-12	1.12E+01
7*	5.00E+00	6.82E-03	4.42E-10	1.07E-11	1.66E-04	1.07E-03	4.00E-12	1.14E+01
8*	1.79E+01	5.04E-02	2.53E-10	6.14E-12	1.23E-03	2.30E-03	3.05E-12	1.15E+01
9*	4.61E+01	1.07E-01	2.45E-10	5.96E-12	2.59E-03	4.89E-03	8.35E-12	1.11E+01
10*	9.80E+01	4.34E-02	5.42E-11	1.32E-12	1.05E-03	5.94E-03	9.31E-13	1.20E+01
=====								
(90 days)		Mean:	5.96E-10	1.45E-11			2.95E-12	1.17E+01
Standard Deviation:			1.63E-10	3.96E-12			7.94E-13	1.75E-01

TABLE H-2. Radionuclide and stable metal leaching data for James A. FitzPatrick mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with pH 10.4. (continued)

Sb-125

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	< 2.10E-04	< 1.62E-10	< 1.07E-10	< 1.39E-04	< 1.39E-04	< 1.87E-12	> 1.17E+01
2*	2.93E-01	< 7.27E-04	< 2.25E-10	< 1.49E-10	< 4.82E-04	< 6.21E-04	< 2.98E-11	> 1.05E+01
3*	1.00E+00	7.79E-04	7.12E-11	4.72E-11	5.16E-04	< 1.14E-03	1.02E-11	1.10E+01
4*	2.00E+00	1.26E-03	8.16E-11	5.41E-11	8.35E-04	< 1.97E-03	3.30E-11	1.05E+01
5*	3.00E+00	< 1.08E-03	< 7.00E-11	< 4.64E-11	< 7.18E-04	< 2.69E-03	< 4.12E-11	> 1.04E+01
6*	4.00E+00	9.32E-04	6.04E-11	4.00E-11	6.18E-04	< 3.31E-03	4.32E-11	1.04E+01
7*	5.00E+00	< 5.41E-04	< 3.50E-11	< 2.32E-11	< 3.58E-04	< 3.67E-03	< 1.87E-11	> 1.07E+01
8*	1.79E+01	< 1.92E-03	< 9.64E-12	< 6.39E-12	< 1.28E-03	< 4.94E-03	< 3.31E-12	> 1.15E+01
9*	4.61E+01	< 2.28E-03	< 5.24E-12	< 3.47E-12	< 1.51E-03	< 6.45E-03	< 2.83E-12	> 1.15E+01
10*	9.80E+01	< 1.58E-03	< 1.98E-12	< 1.31E-12	< 1.05E-03	< 7.50E-03	< 9.25E-13	> 1.20E+01
=====								
(90 days)		Mean:	< 7.22E-11	< 4.79E-11			< 1.85E-11	> 1.10E+01
		Standard Deviation:	2.27E-11	1.51E-11			5.37E-12	1.96E-01

Cs-134

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	8.52E-03	6.57E-09	4.85E-09	6.29E-03	6.29E-03	3.81E-09	8.42E+00
2*	2.93E-01	5.74E-02	1.78E-08	1.31E-08	4.24E-02	4.87E-02	2.30E-07	6.64E+00
3*	1.00E+00	1.23E-01	1.13E-08	8.32E-09	9.10E-02	1.40E-01	3.18E-07	6.50E+00
4*	2.00E+00	1.01E-01	6.55E-09	4.83E-09	7.46E-02	2.14E-01	2.09E-07	6.68E+00
5*	3.00E+00	8.81E-02	5.69E-09	4.20E-09	6.50E-02	2.79E-01	2.47E-07	6.61E+00
6*	4.00E+00	7.17E-02	4.65E-09	3.43E-09	5.29E-02	3.32E-01	2.73E-07	6.56E+00
7*	5.00E+00	5.43E-02	3.51E-09	2.59E-09	4.00E-02	3.72E-01	2.83E-07	6.55E+00
8*	1.79E+01	1.60E-01	8.04E-10	5.94E-10	1.18E-01	4.91E-01	1.53E-07	6.82E+00
9*	4.61E+01	1.04E-01	2.40E-10	1.77E-10	7.71E-02	5.68E-01	8.58E-08	7.07E+00
10*	9.80E+01	7.11E-02	8.88E-11	6.55E-11	5.25E-02	6.20E-01	5.07E-08	7.29E+00
=====								
(90 days)		Mean:	5.72E-09	4.22E-09			1.85E-07	6.91E+00
		Standard Deviation:	1.73E-09	1.28E-09			3.39E-08	1.85E-01

Cs-137

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	1.53E-02	1.18E-08	4.26E-09	5.52E-03	5.52E-03	2.94E-09	8.53E+00
2*	2.93E-01	1.02E-01	3.16E-08	1.15E-08	3.70E-02	4.25E-02	1.75E-07	6.76E+00
3*	1.00E+00	2.27E-01	2.08E-08	7.53E-09	8.23E-02	1.25E-01	2.60E-07	6.58E+00
4*	2.00E+00	1.83E-01	1.18E-08	4.28E-09	6.61E-02	1.91E-01	2.07E-07	6.69E+00
5*	3.00E+00	1.59E-01	1.03E-08	3.71E-09	5.74E-02	2.48E-01	1.92E-07	6.72E+00
6*	4.00E+00	1.29E-01	8.36E-09	3.02E-09	4.67E-02	2.95E-01	2.10E-07	6.68E+00
7*	5.00E+00	9.76E-02	6.32E-09	2.29E-09	3.53E-02	3.30E-01	2.15E-07	6.67E+00
8*	1.79E+01	2.88E-01	1.44E-09	5.23E-10	1.04E-01	4.35E-01	1.14E-07	6.94E+00
9*	4.61E+01	1.88E-01	4.33E-10	1.57E-10	6.81E-02	5.03E-01	6.33E-08	7.20E+00
10*	9.80E+01	1.26E-01	1.58E-10	5.71E-11	4.57E-02	5.48E-01	3.65E-08	7.44E+00
=====								
(90 days)		Mean:	1.03E-08	3.73E-09			1.48E-07	7.02E+00
		Standard Deviation:	3.11E-09	1.12E-09			2.77E-08	1.89E-01

TABLE H-2. Radionuclide and stable metal leaching data for James A. FitzPatrick mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with pH 10.4. (continued)

Pu-241

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.93E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.00E+00	1.02E-05	9.29E-13	9.83E-14	1.07E-06	NA	4.44E-17	1.64E+01
4*	2.00E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.00E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.00E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.00E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.80E+01	NA	NA	NA	NA	NA	NA	NA
(90 days)			Mean:	NA	NA		NA	NA
Standard Deviation:				NA	NA		NA	NA

Fe

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.93E-01	< 1.34E+02	< 4.16E-05	< 1.24E-10	< 4.00E-04	NA	< 2.05E-11	> 1.07E+01
3*	1.00E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.00E+00	< 1.35E+02	< 8.75E-06	< 2.61E-11	< 4.02E-04	NA	< 7.66E-12	> 1.11E+01
5*	3.00E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.00E+00	< 3.73E+01	< 2.42E-06	< 7.20E-12	< 1.11E-04	NA	< 1.40E-12	> 1.19E+01
7*	5.00E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	< 1.32E+02	< 6.62E-07	< 1.97E-12	< 3.93E-04	NA	< 3.15E-13	> 1.25E+01
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.80E+01	< 6.44E+01	< 8.05E-08	< 2.40E-13	< 1.92E-04	NA	< 3.09E-14	> 1.35E+01
(90 days)			Mean:	< 1.07E-05	< 3.19E-11		< 5.99E-12	> 1.19E+01
Standard Deviation:				7.88E-06	2.35E-11		3.89E-12	5.02E-01

Ni

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.93E-01	< 7.16E+01	< 2.22E-05	< 1.36E-09	< 4.38E-03	NA	< 2.46E-09	> 8.61E+00
3*	1.00E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.00E+00	7.47E+01	4.84E-06	2.96E-10	4.57E-03	NA	9.88E-10	9.01E+00
5*	3.00E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.00E+00	5.33E+01	3.45E-06	2.11E-10	3.26E-03	NA	1.20E-09	8.92E+00
7*	5.00E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	1.42E+02	7.09E-07	4.34E-11	8.65E-03	NA	1.52E-10	9.82E+00
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.80E+01	3.97E+01	4.96E-08	3.03E-12	2.43E-03	NA	4.95E-12	1.13E+01
(90 days)			Mean:	6.25E-06	3.82E-10		9.61E-10	9.53E+00
Standard Deviation:				4.08E-06	2.50E-10		4.40E-10	4.86E-01

TABLE H-2. Radionuclide and stable metal leaching data for James A. FitzPatrick mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with pH 10.4. (continued)

Co

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.93E-01	< 8.95E+01	< 2.77E-05	< 7.69E-10	< 2.48E-03	NA	< 7.89E-10	> 9.10E+00
3*	1.00E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.00E+00	< 9.00E+01	< 5.83E-06	< 1.62E-10	< 2.49E-03	NA	< 2.94E-10	> 9.53E+00
5*	3.00E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.00E+00	< 9.00E+01	< 5.84E-06	< 1.62E-10	< 2.49E-03	NA	< 7.04E-10	> 9.15E+00
7*	5.00E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	< 8.80E+01	< 4.41E-07	< 1.22E-11	< 2.44E-03	NA	< 1.21E-11	> 1.09E+01
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.80E+01	< 8.95E+01	< 1.12E-07	< 3.10E-12	< 2.48E-03	NA	< 5.16E-12	> 1.13E+01
=====								
(90 days)		Mean:	< 7.99E-06	< 2.21E-10			< 3.61E-10	> 1.00E+01
Standard Deviation:			5.09E-06	1.41E-10			1.66E-10	4.61E-01

Cr

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.93E-01	< 1.79E+01	< 5.55E-06	< 2.02E-10	< 6.51E-04	NA	< 5.44E-11	> 1.03E+01
3*	1.00E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.00E+00	< 1.80E+01	< 1.17E-06	< 4.24E-11	< 6.55E-04	NA	< 2.03E-11	> 1.07E+01
5*	3.00E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.00E+00	< 1.80E+01	< 1.17E-06	< 4.25E-11	< 6.55E-04	NA	< 4.86E-11	> 1.03E+01
7*	5.00E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	< 1.76E+01	< 8.82E-08	< 3.21E-12	< 6.40E-04	NA	< 8.33E-13	> 1.21E+01
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.80E+01	< 1.79E+01	< 2.24E-08	< 8.13E-13	< 6.51E-04	NA	< 3.56E-13	> 1.24E+01
=====								
(90 days)		Mean:	< 1.60E-06	< 5.81E-11			< 2.49E-11	> 1.12E+01
Standard Deviation:			1.02E-06	3.70E-11			1.15E-11	4.61E-01

TABLE H-3. Radionuclide and stable metal leaching data for James A. FitzPatrick mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with pH 4.2.

Mn-54								
SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	1.14E-02	8.61E-09	4.81E-11	6.40E-05	6.40E-05	3.94E-13	1.24E+01
2*	2.95E-01	4.22E-02	1.29E-08	7.23E-11	2.36E-04	3.00E-04	7.27E-12	1.11E+01
3*	1.01E+00	4.46E-03	4.00E-10	2.24E-12	2.49E-05	3.25E-04	2.39E-14	1.36E+01
4*	2.01E+00	2.57E-03	1.65E-10	9.21E-13	1.44E-05	3.39E-04	9.93E-15	1.40E+01
5*	3.01E+00	1.64E-03	1.05E-10	5.89E-13	9.15E-06	3.48E-04	6.87E-15	1.42E+01
6*	4.01E+00	3.28E-03	2.11E-10	1.18E-12	1.84E-05	3.67E-04	3.87E-14	1.34E+01
7*	5.01E+00	3.55E-03	2.28E-10	1.28E-12	1.99E-05	3.87E-04	5.83E-14	1.32E+01
8*	1.79E+01	1.33E-02	6.62E-11	3.70E-13	7.44E-05	4.61E-04	1.14E-14	1.39E+01
9*	4.61E+01	7.65E-03	1.75E-11	9.76E-14	4.28E-05	5.04E-04	2.31E-15	1.46E+01
10*	9.80E+01	3.78E-02	4.69E-11	2.62E-13	2.11E-04	7.15E-04	3.81E-14	1.34E+01
=====								
(90 days)		Mean:	2.28E-09	1.27E-11			7.85E-13	1.34E+01
Standard Deviation:			1.45E-09	8.12E-12			7.21E-13	3.15E-01
=====								
Co-58								
SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	3.17E-02	2.39E-08	1.28E-10	1.71E-04	1.71E-04	2.80E-12	1.16E+01
2*	2.95E-01	1.09E-01	3.35E-08	1.80E-10	5.88E-04	7.58E-04	4.50E-11	1.03E+01
3*	1.01E+00	1.08E-01	9.71E-09	5.22E-11	5.82E-04	1.34E-03	1.30E-11	1.09E+01
4*	2.01E+00	1.39E-01	8.92E-09	4.80E-11	7.48E-04	2.09E-03	2.69E-11	1.06E+01
5*	3.01E+00	1.08E-01	6.94E-09	3.73E-11	5.79E-04	2.67E-03	2.76E-11	1.06E+01
6*	4.01E+00	1.07E-01	6.85E-09	3.68E-11	5.73E-04	3.24E-03	3.77E-11	1.04E+01
7*	5.01E+00	9.38E-02	6.03E-09	3.24E-11	5.04E-04	3.74E-03	3.76E-11	1.04E+01
8*	1.79E+01	4.42E-01	2.20E-09	1.18E-11	2.38E-03	6.12E-03	1.16E-11	1.09E+01
9*	4.61E+01	5.48E-01	1.25E-09	6.72E-12	2.95E-03	9.07E-03	1.09E-11	1.10E+01
10*	9.80E+01	6.03E-01	7.47E-10	4.01E-12	3.24E-03	1.23E-02	8.93E-12	1.10E+01
=====								
(90 days)		Mean:	1.00E-08	5.38E-11			2.22E-11	1.08E+01
Standard Deviation:			3.34E-09	1.79E-11			4.63E-12	1.19E-01
=====								
Co-60								
SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	1.73E-01	1.30E-07	1.85E-10	2.46E-04	2.46E-04	5.83E-12	1.12E+01
2*	2.95E-01	5.89E-01	1.80E-07	2.57E-10	8.38E-04	1.08E-03	9.16E-11	1.00E+01
3*	1.01E+00	5.85E-01	5.25E-08	7.47E-11	8.32E-04	1.92E-03	2.66E-11	1.06E+01
4*	2.01E+00	7.47E-01	4.79E-08	6.81E-11	1.06E-03	2.98E-03	5.43E-11	1.03E+01
5*	3.01E+00	5.82E-01	3.75E-08	5.33E-11	8.28E-04	3.81E-03	5.63E-11	1.02E+01
6*	4.01E+00	5.79E-01	3.72E-08	5.30E-11	8.24E-04	4.63E-03	7.80E-11	1.01E+01
7*	5.01E+00	5.11E-01	3.28E-08	4.67E-11	7.27E-04	5.36E-03	7.81E-11	1.01E+01
8*	1.79E+01	2.40E+00	1.19E-08	1.70E-11	3.42E-03	8.77E-03	2.40E-11	1.06E+01
9*	4.61E+01	3.01E+00	6.88E-09	9.79E-12	4.29E-03	1.31E-02	2.32E-11	1.06E+01
10*	9.80E+01	3.26E+00	4.04E-09	5.76E-12	4.65E-03	1.77E-02	1.84E-11	1.07E+01
=====								
(90 days)		Mean:	5.41E-08	7.70E-11			4.56E-11	1.05E+01
Standard Deviation:			1.80E-08	2.57E-11			9.47E-12	1.18E-01
=====								

TABLE H-3. Radionuclide and stable metal leaching data for James A. FitzPatrick mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with pH 4.2. (continued)

Ni-63

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	2.67E-02	2.01E-08	8.35E-10	1.11E-03	1.11E-03	1.19E-10	9.93E+00
2*	2.95E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.01E+00	3.32E-01	2.98E-08	1.24E-09	1.38E-02	NA	7.34E-09	8.13E+00
4*	2.01E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.01E+00	2.67E-01	1.72E-08	7.16E-10	1.11E-02	NA	1.02E-08	7.99E+00
6*	4.01E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.01E+00	1.37E-01	8.81E-09	3.66E-10	5.70E-03	NA	4.81E-09	8.32E+00
8*	1.79E+01	3.06E-01	1.52E-09	6.33E-11	1.27E-02	NA	3.34E-10	9.48E+00
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.80E+01	3.99E-02	4.94E-11	2.05E-12	1.66E-03	NA	2.34E-12	1.16E+01
=====								
(90 days)		Mean:	1.29E-08	5.37E-10			3.79E-09	9.25E+00
Standard Deviation:			4.72E-09	1.96E-10			1.77E-09	5.74E-01

Zn-65

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	5.85E-03	4.40E-09	1.05E-10	1.40E-04	1.40E-04	1.88E-12	1.17E+01
2*	2.95E-01	1.86E-02	5.69E-09	1.36E-10	4.45E-04	5.85E-04	2.58E-11	1.06E+01
3*	1.01E+00	6.60E-03	5.92E-10	1.42E-11	1.58E-04	7.43E-04	9.60E-13	1.20E+01
4*	2.01E+00	7.52E-03	4.82E-10	1.15E-11	1.80E-04	9.23E-04	1.56E-12	1.18E+01
5*	3.01E+00	5.42E-03	3.49E-10	8.36E-12	1.30E-04	1.05E-03	1.38E-12	1.19E+01
6*	4.01E+00	6.87E-03	4.42E-10	1.06E-11	1.64E-04	1.22E-03	3.11E-12	1.15E+01
7*	5.01E+00	6.18E-03	3.97E-10	9.50E-12	1.48E-04	1.36E-03	3.23E-12	1.15E+01
8*	1.79E+01	3.55E-02	1.77E-10	4.22E-12	8.50E-04	2.21E-03	1.49E-12	1.18E+01
9*	4.61E+01	3.47E-02	7.92E-11	1.89E-12	8.31E-04	3.05E-03	8.69E-13	1.21E+01
10*	9.80E+01	8.80E-02	1.09E-10	2.61E-12	2.11E-03	5.15E-03	3.78E-12	1.14E+01
=====								
(90 days)		Mean:	1.27E-09	3.04E-11			4.40E-12	1.16E+01
Standard Deviation:			6.38E-10	1.53E-11			2.40E-12	1.35E-01

Sb-125

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	< 3.65E-04	< 2.74E-10	< 1.79E-10	< 2.38E-04	< 2.38E-04	< 5.45E-12	> 1.13E+01
2*	2.95E-01	< 9.14E-04	< 2.80E-10	< 1.83E-10	< 5.97E-04	< 8.35E-04	< 4.65E-11	> 1.03E+01
3*	1.01E+00	< 8.01E-04	< 7.19E-11	< 4.70E-11	< 5.23E-04	< 1.36E-03	< 1.05E-11	> 1.10E+01
4*	2.01E+00	< 1.05E-03	< 6.72E-11	< 4.39E-11	< 6.84E-04	< 2.04E-03	< 2.25E-11	> 1.06E+01
5*	3.01E+00	< 1.38E-03	< 8.88E-11	< 5.80E-11	< 9.01E-04	< 2.94E-03	< 6.66E-11	> 1.02E+01
6*	4.01E+00	9.13E-04	5.87E-11	3.83E-11	5.96E-04	< 3.54E-03	4.09E-11	1.04E+01
7*	5.01E+00	< 6.60E-04	< 4.24E-11	< 2.77E-11	< 4.31E-04	< 3.97E-03	< 2.74E-11	> 1.06E+01
8*	1.79E+01	< 1.87E-03	< 9.29E-12	< 6.07E-12	< 1.22E-03	< 5.19E-03	< 3.07E-12	> 1.15E+01
9*	4.61E+01	< 1.37E-03	< 3.12E-12	< 2.04E-12	< 8.93E-04	< 6.08E-03	< 1.00E-12	> 1.20E+01
10*	9.80E+01	< 2.19E-03	< 2.71E-12	< 1.77E-12	< 1.43E-03	< 7.51E-03	< 1.74E-12	> 1.18E+01
=====								
(90 days)		Mean:	< 8.98E-11	< 5.87E-11			< 2.26E-11	> 1.10E+01
Standard Deviation:			3.26E-11	2.13E-11			7.14E-12	2.03E-01

TABLE H-3. Radionuclide and stable metal leaching data for James A. FitzPatrick mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with pH 4.2. (continued)

Cs-134

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	2.74E-02	2.06E-08	1.50E-08	1.99E-02	1.99E-02	3.81E-08	7.42E+00
2*	2.95E-01	6.71E-02	2.06E-08	1.50E-08	4.88E-02	6.87E-02	3.11E-07	6.51E+00
3*	1.01E+00	1.14E-01	1.02E-08	7.43E-09	8.28E-02	1.51E-01	2.64E-07	6.58E+00
4*	2.01E+00	1.43E-01	9.16E-09	6.66E-09	1.04E-01	2.55E-01	3.07E-07	6.51E+00
5*	3.01E+00	9.99E-02	6.43E-09	4.68E-09	7.27E-02	3.28E-01	3.59E-07	6.45E+00
6*	4.01E+00	8.25E-02	5.31E-09	3.86E-09	6.00E-02	3.88E-01	3.96E-07	6.40E+00
7*	5.01E+00	5.96E-02	3.83E-09	2.78E-09	4.33E-02	4.31E-01	3.83E-07	6.42E+00
8*	1.79E+01	1.79E-01	8.91E-10	6.48E-10	1.30E-01	5.62E-01	2.17E-07	6.66E+00
9*	4.61E+01	1.10E-01	2.50E-10	1.82E-10	7.97E-02	6.41E-01	1.20E-07	6.92E+00
10*	9.80E+01	5.98E-02	7.40E-11	5.38E-11	4.34E-02	6.85E-01	6.84E-08	7.16E+00
=====								
(90 days)		Mean:	7.73E-09	5.62E-09			2.46E-07	6.70E+00
Standard Deviation:			2.41E-09	1.75E-09			4.13E-08	1.11E-01

Cs-137

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	4.89E-02	3.68E-08	1.31E-08	1.74E-02	1.74E-02	2.93E-08	7.53E+00
2*	2.95E-01	1.21E-01	3.72E-08	1.32E-08	4.32E-02	6.07E-02	2.44E-07	6.61E+00
3*	1.01E+00	2.04E-01	1.83E-08	6.54E-09	7.29E-02	1.34E-01	2.04E-07	6.69E+00
4*	2.01E+00	2.64E-01	1.69E-08	6.04E-09	9.42E-02	2.28E-01	2.41E-07	6.62E+00
5*	3.01E+00	1.79E-01	1.15E-08	4.11E-09	6.39E-02	2.92E-01	2.77E-07	6.56E+00
6*	4.01E+00	1.47E-01	9.47E-09	3.38E-09	5.25E-02	3.44E-01	3.00E-07	6.52E+00
7*	5.01E+00	1.06E-01	6.83E-09	2.43E-09	3.79E-02	3.82E-01	3.05E-07	6.52E+00
8*	1.79E+01	3.22E-01	1.60E-09	5.71E-10	1.15E-01	4.97E-01	1.60E-07	6.80E+00
9*	4.61E+01	1.98E-01	4.51E-10	1.61E-10	7.05E-02	5.68E-01	8.73E-08	7.06E+00
10*	9.80E+01	1.08E-01	1.34E-10	4.79E-11	3.86E-02	6.06E-01	4.87E-08	7.31E+00
=====								
(90 days)		Mean:	1.39E-08	4.97E-09			1.90E-07	6.82E+00
Standard Deviation:			4.34E-09	1.55E-09			3.27E-08	1.14E-01

Pu-241

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.95E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.01E+00	3.45E-05	3.09E-12	3.23E-13	3.59E-06	NA	4.97E-16	1.53E+01
4*	2.01E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.01E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.01E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.80E+01	NA	NA	NA	NA	NA	NA	NA
=====								
(90 days)		Mean:	NA	NA			NA	NA
Standard Deviation:			NA	NA			NA	NA

TABLE H-3. Radionuclide and stable metal leaching data for James A. FitzPatrick mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with pH 4.2. (continued)

Fe

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.95E-01	< 2.84E+02	< 8.69E-05	< 2.55E-10	< 8.33E-04	NA	< 9.04E-11	> 1.00E+01
3*	1.01E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.01E+00	< 5.02E+01	< 3.22E-06	< 9.45E-12	< 1.47E-04	NA	< 1.05E-12	> 1.20E+01
5*	3.01E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.01E+00	< 1.35E+02	< 8.68E-06	< 2.55E-11	< 3.96E-04	NA	< 1.81E-11	> 1.07E+01
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	< 1.33E+02	< 6.60E-07	< 1.94E-12	< 3.90E-04	NA	< 3.13E-13	> 1.25E+01
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.80E+01	< 1.65E+02	< 2.04E-07	< 6.00E-13	< 4.84E-04	NA	< 1.99E-13	> 1.27E+01
=====								
(90 days)		Mean:	< 1.99E-05	< 5.85E-11			< 2.20E-11	> 1.16E+01
Standard Deviation:			1.68E-05	4.93E-11			1.74E-11	5.16E-01

Ni

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.95E-01	3.20E+01	9.79E-06	5.90E-10	1.92E-03	NA	4.83E-10	9.32E+00
3*	1.01E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.01E+00	9.50E+01	6.09E-06	3.67E-10	5.73E-03	NA	1.58E-09	8.80E+00
5*	3.01E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.01E+00	5.92E+01	3.81E-06	2.29E-10	3.57E-03	NA	1.46E-09	8.83E+00
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	1.49E+02	7.39E-07	4.45E-11	8.96E-03	NA	1.65E-10	9.78E+00
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.80E+01	6.18E+01	7.65E-08	4.61E-12	3.72E-03	NA	1.18E-11	1.09E+01
=====								
(90 days)		Mean:	4.10E-06	2.47E-10			7.40E-10	9.53E+00
Standard Deviation:			1.79E-06	1.08E-10			3.28E-10	3.92E-01

Co

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.95E-01	< 8.98E+01	< 2.75E-05	< 7.50E-10	< 2.45E-03	NA	< 7.83E-10	> 9.11E+00
3*	1.01E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.01E+00	< 9.00E+01	< 5.77E-06	< 1.57E-10	< 2.46E-03	NA	< 2.90E-10	> 9.54E+00
5*	3.01E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.01E+00	< 9.00E+01	< 5.79E-06	< 1.58E-10	< 2.46E-03	NA	< 6.94E-10	> 9.16E+00
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	< 8.85E+01	< 4.40E-07	< 1.20E-11	< 2.42E-03	NA	< 1.20E-11	> 1.09E+01
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.80E+01	< 8.90E+01	< 1.10E-07	< 3.01E-12	< 2.43E-03	NA	< 5.02E-12	> 1.13E+01
=====								
(90 days)		Mean:	< 7.92E-06	< 2.16E-10			< 3.57E-10	> 1.00E+01
Standard Deviation:			5.05E-06	1.38E-10			1.65E-10	4.61E-01

TABLE H-3. Radionuclide and stable metal leaching data for James A. FitzPatrick mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with pH 4.2. (continued)

Cr

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.95E-01	< 1.79E+01	< 5.50E-06	< 1.97E-10	< 6.43E-04	NA	< 5.40E-11	> 1.03E+01
3*	1.01E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.01E+00	< 1.80E+01	< 1.15E-06	< 4.14E-11	< 6.45E-04	NA	< 2.00E-11	> 1.07E+01
5*	3.01E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.01E+00	< 1.80E+01	< 1.16E-06	< 4.15E-11	< 6.45E-04	NA	< 4.78E-11	> 1.03E+01
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	< 1.77E+01	< 8.80E-08	< 3.15E-12	< 6.34E-04	NA	< 8.29E-13	> 1.21E+01
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.80E+01	< 1.78E+01	< 2.21E-08	< 7.90E-13	< 6.38E-04	NA	< 3.46E-13	> 1.25E+01
=====								
(90 days)		Mean:	< 1.58E-06	< 5.68E-11			< 2.46E-11	> 1.12E+01
Standard Deviation:			1.01E-06	3.62E-11			1.14E-11	4.61E-01

TABLE H-4. Radionuclide and stable metal leaching data for James A. FitzPatrick mixed-bed resin waste-form specimen leached in synthetic Hanford ground water with pH 8.9.

Mn-54

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.61E-02	1.57E-03	1.16E-09	6.43E-12	8.68E-06	8.68E-06	7.22E-15	1.41E+01
2*	2.97E-01	3.60E-03	1.09E-09	6.01E-12	1.98E-05	2.85E-05	5.15E-14	1.33E+01
3*	1.01E+00	1.58E-03	1.41E-10	7.76E-13	8.69E-06	3.72E-05	2.94E-15	1.45E+01
4*	2.01E+00	8.28E-04	5.27E-11	2.91E-13	4.57E-06	4.18E-05	1.01E-15	1.50E+01
5*	3.01E+00	4.94E-04	3.14E-11	1.73E-13	2.72E-06	4.45E-05	6.08E-16	1.52E+01
6*	4.01E+00	2.80E-03	1.78E-10	9.83E-13	1.54E-05	5.99E-05	2.74E-14	1.36E+01
7*	5.01E+00	1.55E-03	9.83E-11	5.42E-13	8.53E-06	6.85E-05	1.07E-14	1.40E+01
8*	1.79E+01	4.01E-03	1.97E-11	1.09E-13	2.21E-05	9.06E-05	1.01E-15	1.50E+01
9*	4.61E+01	2.83E-03	6.40E-12	3.53E-14	1.56E-05	1.06E-04	3.08E-16	1.55E+01
10*	9.79E+01	3.31E-03	4.07E-12	2.24E-14	1.83E-05	1.24E-04	2.85E-16	1.55E+01
(90 days)			Mean:	2.79E-10	1.54E-12		1.03E-14	1.46E+01
Standard Deviation:				1.43E-10	7.87E-13		5.30E-15	2.54E-01

Fe-55

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.61E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.97E-01	5.92E-03	1.79E-09	1.82E-10	6.01E-04	NA	4.72E-11	1.03E+01
3*	1.01E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.01E+00	8.72E-03	5.55E-10	5.63E-11	8.84E-04	NA	3.78E-11	1.04E+01
5*	3.01E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.01E+00	3.10E-03	1.98E-10	2.00E-11	3.14E-04	NA	1.14E-11	1.09E+01
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	3.05E-03	1.50E-11	1.52E-12	3.09E-04	NA	1.98E-13	1.27E+01
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.79E+01	1.18E-02	1.45E-11	1.47E-12	1.20E-03	NA	1.23E-12	1.19E+01
(90 days)			Mean:	5.15E-10	5.22E-11		1.96E-11	1.13E+01
Standard Deviation:				3.34E-10	3.39E-11		9.68E-12	4.57E-01

Co-58

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.61E-02	1.41E-02	1.04E-08	5.53E-11	7.47E-05	7.47E-05	5.35E-13	1.23E+01
2*	2.97E-01	4.80E-02	1.45E-08	7.71E-11	2.55E-04	3.29E-04	8.48E-12	1.11E+01
3*	1.01E+00	1.02E-01	9.12E-09	4.84E-11	5.41E-04	8.71E-04	1.14E-11	1.09E+01
4*	2.01E+00	8.43E-02	5.37E-09	2.85E-11	4.47E-04	1.32E-03	9.66E-12	1.10E+01
5*	3.01E+00	8.22E-02	5.23E-09	2.78E-11	4.36E-04	1.75E-03	1.56E-11	1.08E+01
6*	4.01E+00	6.76E-02	4.31E-09	2.29E-11	3.59E-04	2.11E-03	1.48E-11	1.08E+01
7*	5.01E+00	6.46E-02	4.10E-09	2.18E-11	3.42E-04	2.45E-03	1.73E-11	1.08E+01
8*	1.79E+01	3.36E-01	1.65E-09	8.77E-12	1.78E-03	4.23E-03	6.56E-12	1.12E+01
9*	4.61E+01	3.99E-01	9.03E-10	4.79E-12	2.12E-03	6.35E-03	5.67E-12	1.12E+01
10*	9.79E+01	4.64E-01	5.70E-10	3.02E-12	2.46E-03	8.81E-03	5.17E-12	1.13E+01
(90 days)			Mean:	5.62E-09	2.98E-11		9.52E-12	1.11E+01
Standard Deviation:				1.42E-09	7.55E-12		1.68E-12	1.38E-01

TABLE H-4. Radionuclide and stable metal leaching data for James A. FitzPatrick mixed-bed resin waste-form specimen leached in synthetic Hanford ground water with pH 8.9. (continued)

Co-60

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.61E-02	7.34E-02	5.43E-08	7.62E-11	1.03E-04	1.03E-04	1.02E-12	1.20E+01
2*	2.97E-01	2.58E-01	7.82E-08	1.10E-10	3.63E-04	4.66E-04	1.72E-11	1.08E+01
3*	1.01E+00	5.48E-01	4.90E-08	6.88E-11	7.70E-04	1.24E-03	2.31E-11	1.06E+01
4*	2.01E+00	4.60E-01	2.93E-08	4.11E-11	6.45E-04	1.88E-03	2.01E-11	1.07E+01
5*	3.01E+00	4.54E-01	2.89E-08	4.06E-11	6.37E-04	2.52E-03	3.33E-11	1.05E+01
6*	4.01E+00	3.63E-01	2.31E-08	3.25E-11	5.10E-04	3.03E-03	3.00E-11	1.05E+01
7*	5.01E+00	3.47E-01	2.20E-08	3.09E-11	4.87E-04	3.52E-03	3.50E-11	1.05E+01
8*	1.79E+01	1.82E+00	8.97E-09	1.26E-11	2.56E-03	6.07E-03	1.35E-11	1.09E+01
9*	4.61E+01	2.18E+00	4.92E-09	6.91E-12	3.05E-03	9.12E-03	1.18E-11	1.09E+01
10*	9.79E+01	2.53E+00	3.11E-09	4.37E-12	3.55E-03	1.27E-02	1.08E-11	1.10E+01
=====								
(90 days)		Mean:	3.02E-08	4.24E-11			1.96E-11	1.08E+01
		Standard Deviation:	7.59E-09	1.07E-11			3.45E-12	1.41E-01

Ni-63

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.61E-02	9.42E-03	6.97E-09	2.86E-10	3.86E-04	3.86E-04	1.43E-11	1.08E+01
2*	2.97E-01	1.30E-01	3.95E-08	1.62E-09	5.35E-03	5.73E-03	3.74E-09	8.43E+00
3*	1.01E+00	2.88E-01	2.57E-08	1.06E-09	1.18E-02	1.76E-02	5.44E-09	8.26E+00
4*	2.01E+00	3.76E-01	2.39E-08	9.82E-10	1.54E-02	3.30E-02	1.15E-08	7.94E+00
5*	3.01E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.01E+00	1.75E-01	1.11E-08	4.57E-10	7.17E-03	NA	5.92E-09	8.23E+00
7*	5.01E+00	1.59E-01	1.01E-08	4.15E-10	6.53E-03	NA	6.29E-09	8.20E+00
8*	1.79E+01	3.36E-01	1.66E-09	6.80E-11	1.38E-02	NA	3.94E-10	9.40E+00
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.79E+01	2.17E-01	2.66E-10	1.09E-11	8.89E-03	NA	6.75E-11	1.02E+01
=====								
(90 days)		Mean:	1.49E-08	6.12E-10			4.17E-09	8.93E+00
		Standard Deviation:	4.80E-09	1.97E-10			1.41E-09	3.81E-01

Zn-65

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.61E-02	4.09E-04	3.03E-10	7.15E-12	9.67E-06	9.67E-06	8.95E-15	1.40E+01
2*	2.97E-01	3.36E-03	1.02E-09	2.41E-11	7.94E-05	8.91E-05	8.26E-13	1.21E+01
3*	1.01E+00	1.71E-03	1.53E-10	3.61E-12	4.04E-05	1.30E-04	6.37E-14	1.32E+01
4*	2.01E+00	1.35E-03	8.58E-11	2.02E-12	3.18E-05	1.61E-04	4.89E-14	1.33E+01
5*	3.01E+00	1.51E-03	9.62E-11	2.27E-12	3.57E-05	1.97E-04	1.04E-13	1.30E+01
6*	4.01E+00	2.10E-03	1.34E-10	3.17E-12	4.97E-05	2.47E-04	2.85E-13	1.25E+01
7*	5.01E+00	1.74E-03	1.11E-10	2.61E-12	4.11E-05	2.88E-04	2.49E-13	1.26E+01
8*	1.79E+01	1.26E-02	6.20E-11	1.46E-12	2.97E-04	5.85E-04	1.82E-13	1.27E+01
9*	4.61E+01	1.80E-02	4.07E-11	9.60E-13	4.24E-04	1.01E-03	2.28E-13	1.26E+01
10*	9.79E+01	2.48E-02	3.05E-11	7.21E-13	5.87E-04	1.60E-03	2.94E-13	1.25E+01
=====								
(90 days)		Mean:	2.03E-10	4.80E-12			2.29E-13	1.29E+01
		Standard Deviation:	9.38E-11	2.22E-12			7.38E-14	1.73E-01

TABLE H-4. Radionuclide and stable metal leaching data for James A. FitzPatrick mixed-bed resin waste-form specimen leached in synthetic Hanford ground water with pH 8.9. (continued)

Sb-125

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.61E-02	< 2.46E-04	< 1.82E-10	< 1.17E-10	< 1.59E-04	< 1.59E-04	< 2.41E-12	> 1.16E+01
2*	2.97E-01	< 6.19E-04	< 1.87E-10	< 1.21E-10	< 3.99E-04	< 5.57E-04	< 2.08E-11	> 1.07E+01
3*	1.01E+00	< 7.50E-04	< 6.70E-11	< 4.31E-11	< 4.83E-04	< 1.04E-03	< 9.08E-12	> 1.10E+01
4*	2.01E+00	< 1.07E-03	< 6.79E-11	< 4.38E-11	< 6.88E-04	< 1.73E-03	< 2.29E-11	> 1.06E+01
5*	3.01E+00	< 7.35E-04	< 4.68E-11	< 3.01E-11	< 4.73E-04	< 2.20E-03	< 1.84E-11	> 1.07E+01
6*	4.01E+00	< 1.11E-03	< 7.06E-11	< 4.55E-11	< 7.14E-04	< 2.92E-03	< 5.88E-11	> 1.02E+01
7*	5.01E+00	< 8.73E-04	< 5.55E-11	< 3.58E-11	< 5.63E-04	< 3.48E-03	< 4.68E-11	> 1.03E+01
8*	1.79E+01	< 1.07E-03	< 5.27E-12	< 3.40E-12	< 6.89E-04	< 4.17E-03	< 9.82E-13	> 1.20E+01
9*	4.61E+01	< 1.15E-03	< 2.60E-12	< 1.67E-12	< 7.40E-04	< 4.91E-03	< 6.93E-13	> 1.22E+01
10*	9.79E+01	< 1.07E-03	< 1.32E-12	< 8.51E-13	< 6.92E-04	< 5.60E-03	< 4.09E-13	> 1.24E+01
=====								
(90 days)		Mean:	< 6.86E-11	< 4.42E-11				
Standard Deviation:			2.12E-11	1.37E-11				
							< 1.81E-11	> 1.12E+01
							6.45E-12	2.51E-01

Cs-134

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.61E-02	1.32E-02	9.76E-09	7.00E-09	9.46E-03	9.46E-03	8.57E-09	8.07E+00
2*	2.97E-01	5.21E-02	1.58E-08	1.13E-08	3.73E-02	4.68E-02	1.82E-07	6.74E+00
3*	1.01E+00	1.25E-01	1.11E-08	7.99E-09	8.95E-02	1.36E-01	3.12E-07	6.51E+00
4*	2.01E+00	1.11E-01	7.05E-09	5.06E-09	7.94E-02	2.16E-01	2.15E-07	6.67E+00
5*	3.01E+00	9.16E-02	5.83E-09	4.18E-09	6.57E-02	2.81E-01	2.54E-07	6.59E+00
6*	4.01E+00	6.19E-02	3.94E-09	2.83E-09	4.44E-02	3.26E-01	2.66E-07	6.57E+00
7*	5.01E+00	5.20E-02	3.30E-09	2.37E-09	3.73E-02	3.63E-01	2.72E-07	6.57E+00
8*	1.79E+01	1.90E-01	9.37E-10	6.72E-10	1.36E-01	4.99E-01	1.61E-07	6.79E+00
9*	4.61E+01	1.42E-01	3.22E-10	2.31E-10	1.02E-01	6.01E-01	6.66E-08	7.18E+00
10*	9.79E+01	8.68E-02	1.07E-10	7.65E-11	6.22E-02	6.64E-01	6.24E-08	7.20E+00
=====								
(90 days)		Mean:	5.81E-09	4.17E-09				
Standard Deviation:			1.64E-09	1.17E-09				
							1.80E-07	6.89E+00
							3.27E-08	1.52E-01

Cs-137

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.61E-02	2.39E-02	1.77E-08	6.22E-09	8.41E-03	8.41E-03	6.77E-09	8.17E+00
2*	2.97E-01	9.37E-02	2.84E-08	9.98E-09	3.30E-02	4.14E-02	1.42E-07	6.85E+00
3*	1.01E+00	2.28E-01	2.04E-08	7.16E-09	8.02E-02	1.22E-01	2.50E-07	6.60E+00
4*	2.01E+00	1.98E-01	1.26E-08	4.43E-09	6.95E-02	1.91E-01	2.34E-07	6.63E+00
5*	3.01E+00	1.67E-01	1.06E-08	3.74E-09	5.88E-02	2.50E-01	1.97E-07	6.71E+00
6*	4.01E+00	1.12E-01	7.11E-09	2.50E-09	3.92E-02	2.89E-01	2.04E-07	6.69E+00
7*	5.01E+00	9.24E-02	5.87E-09	2.06E-09	3.25E-02	3.22E-01	2.07E-07	6.68E+00
8*	1.79E+01	3.41E-01	1.68E-09	5.91E-10	1.20E-01	4.42E-01	1.20E-07	6.92E+00
9*	4.61E+01	2.57E-01	5.81E-10	2.05E-10	9.04E-02	5.32E-01	7.33E-08	7.13E+00
10*	9.79E+01	1.55E-01	1.91E-10	6.72E-11	5.47E-02	5.87E-01	4.48E-08	7.35E+00
=====								
(90 days)		Mean:	1.05E-08	3.70E-09				
Standard Deviation:			2.96E-09	1.04E-09				
							1.48E-07	6.97E+00
							2.66E-08	1.53E-01

TABLE H-4. Radionuclide and stable metal leaching data for James A. FitzPatrick mixed-bed resin waste-form specimen leached in synthetic Hanford ground water with pH 8.9. (continued)

Pu-241

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.61E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.97E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.01E+00	6.08E-06	5.44E-13	5.59E-14	6.26E-07	NA	1.53E-17	1.68E+01
4*	2.01E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.01E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.01E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.79E+01	NA	NA	NA	NA	NA	NA	NA
(90 days)			Mean:	NA	NA		NA	NA
Standard Deviation:				NA	NA		NA	NA

Fe

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.61E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.97E-01	< 1.34E+02	< 4.05E-05	< 1.17E-10	< 3.88E-04	NA	< 1.97E-11	> 1.07E+01
3*	1.01E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.01E+00	< 1.34E+02	< 8.55E-06	< 2.48E-11	< 3.89E-04	NA	< 7.31E-12	> 1.11E+01
5*	3.01E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.01E+00	< 1.80E+02	< 1.15E-05	< 3.32E-11	< 5.21E-04	NA	< 3.13E-11	> 1.05E+01
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	< 1.33E+02	< 6.54E-07	< 1.90E-12	< 3.85E-04	NA	< 3.06E-13	> 1.25E+01
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.79E+01	< 1.34E+02	< 1.65E-07	< 4.78E-13	< 3.89E-04	NA	< 1.29E-13	> 1.29E+01
(90 days)			Mean:	< 1.23E-05	< 3.56E-11		< 1.18E-11	> 1.15E+01
Standard Deviation:				7.40E-06	2.14E-11		6.05E-12	4.85E-01

Ni

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.61E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.97E-01	< 7.14E+01	< 2.16E-05	< 5.82E-10	< 1.92E-03	NA	< 4.84E-10	9.32E+00
3*	1.01E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.01E+00	6.21E+01	3.95E-06	1.07E-10	1.67E-03	NA	1.35E-10	9.87E+00
5*	3.01E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.01E+00	4.05E+01	2.58E-06	6.95E-11	1.09E-03	NA	1.37E-10	9.86E+00
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	1.62E+02	8.01E-07	2.16E-11	4.38E-03	NA	3.96E-11	1.04E+01
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.79E+01	7.55E+01	9.28E-08	2.50E-12	2.03E-03	NA	3.54E-12	1.15E+01
(90 days)			Mean:	5.81E-06	1.56E-10		1.60E-10	1.02E+01
Standard Deviation:				4.63E-06	1.25E-10		9.83E-11	4.17E-01

TABLE H-4. Radionuclide and stable metal leaching data for James A. FitzPatrick mixed-bed resin waste-form specimen leached in synthetic Hanford ground water with pH 8.9. (continued)

Co

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.61E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.97E-01	< 8.92E+01	< 2.70E-05	< 7.28E-10	< 2.40E-03	NA	< 7.56E-10	> 9.12E+00
3*	1.01E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.01E+00	< 8.95E+01	< 5.70E-06	< 1.53E-10	< 2.41E-03	NA	< 2.81E-10	> 9.55E+00
5*	3.01E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.01E+00	< 9.00E+01	< 5.73E-06	< 1.54E-10	< 2.42E-03	NA	< 6.77E-10	> 9.17E+00
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	< 8.85E+01	< 4.36E-07	< 1.17E-11	< 2.38E-03	NA	< 1.18E-11	> 1.09E+01
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.79E+01	< 8.95E+01	< 1.10E-07	< 2.96E-12	< 2.41E-03	NA	< 4.96E-12	> 1.13E+01
=====								
(90 days)		Mean:	< 7.80E-06	< 2.10E-10			< 3.46E-10	> 1.00E+01
Standard Deviation:			4.96E-06	1.34E-10			1.60E-10	4.60E-01

Cr

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.61E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.97E-01	< 1.79E+01	< 5.41E-06	< 1.91E-10	< 6.31E-04	NA	< 5.21E-11	> 1.03E+01
3*	1.01E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.01E+00	< 1.79E+01	< 1.14E-06	< 4.03E-11	< 6.33E-04	NA	< 1.94E-11	> 1.07E+01
5*	3.01E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.01E+00	< 1.80E+01	< 1.15E-06	< 4.06E-11	< 6.36E-04	NA	< 4.67E-11	> 1.03E+01
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	< 1.77E+01	< 8.72E-08	< 3.08E-12	< 6.26E-04	NA	< 8.10E-13	> 1.21E+01
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.79E+01	< 1.79E+01	< 2.20E-08	< 7.78E-13	< 6.33E-04	NA	< 3.42E-13	> 1.25E+01
=====								
(90 days)		Mean:	< 1.56E-06	< 5.52E-11			< 2.39E-11	> 1.12E+01
Standard Deviation:			9.92E-07	3.51E-11			1.10E-11	4.60E-01

TABEL H-5. Radionuclide and stable metal leaching data for James A. FitzPatrick mixed-bed resin waste-form specimen leached in synthetic seawater with pH 6.4.

Mn-54

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	3.83E-04	2.90E-10	1.62E-12	2.13E-06	2.13E-06	4.37E-16	1.54E+01
2*	2.97E-01	1.19E-03	3.62E-10	2.02E-12	6.64E-06	8.77E-06	5.60E-15	1.43E+01
3*	1.01E+00	9.19E-04	8.24E-11	4.59E-13	5.12E-06	1.39E-05	9.99E-16	1.50E+01
4*	2.02E+00	6.69E-04	4.29E-11	2.39E-13	3.72E-06	1.76E-05	6.63E-16	1.52E+01
5*	3.01E+00	6.11E-04	3.94E-11	2.19E-13	3.40E-06	2.10E-05	9.45E-16	1.50E+01
6*	4.01E+00	< 2.67E-04	< 1.72E-11	< 9.55E-14	< 1.48E-06	< 2.25E-05	< 2.52E-16	> 1.56E+01
7*	5.01E+00	4.69E-04	3.03E-11	1.68E-13	2.61E-06	< 2.51E-05	1.01E-15	1.50E+01
8*	1.79E+01	< 1.21E-03	< 6.03E-12	< 3.36E-14	< 6.75E-06	< 3.18E-05	< 9.31E-17	> 1.60E+01
9*	4.61E+01	< 1.04E-03	< 2.38E-12	< 1.33E-14	< 5.80E-06	< 3.77E-05	< 4.21E-17	> 1.64E+01
10*	9.79E+01	< 1.26E-03	< 1.56E-12	< 8.68E-15	< 6.99E-06	< 4.46E-05	< 4.14E-17	> 1.64E+01
=====								
(90 days)		Mean:	< 8.75E-11	< 4.87E-13				
Standard Deviation:			4.09E-11	2.28E-13				
							< 1.01E-15	> 1.54E+01
							5.25E-16	2.16E-01

Co-58

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	2.09E-02	1.58E-08	8.48E-11	1.12E-04	1.12E-04	1.20E-12	1.19E+01
2*	2.97E-01	1.12E-01	3.40E-08	1.82E-10	6.00E-04	7.12E-04	4.57E-11	1.03E+01
3*	1.01E+00	1.52E-01	1.37E-08	7.31E-11	8.15E-04	1.53E-03	2.54E-11	1.06E+01
4*	2.02E+00	1.08E-01	6.90E-09	3.69E-11	5.76E-04	2.10E-03	1.58E-11	1.08E+01
5*	3.01E+00	8.44E-02	5.44E-09	2.91E-11	4.52E-04	2.55E-03	1.67E-11	1.08E+01
6*	4.01E+00	7.39E-02	4.76E-09	2.55E-11	3.95E-04	2.95E-03	1.79E-11	1.07E+01
7*	5.01E+00	6.37E-02	4.12E-09	2.20E-11	3.41E-04	3.29E-03	1.72E-11	1.08E+01
8*	1.79E+01	5.57E-01	2.77E-09	1.48E-11	2.98E-03	6.27E-03	1.82E-11	1.07E+01
9*	4.61E+01	7.20E-01	1.64E-09	8.80E-12	3.85E-03	1.01E-02	1.86E-11	1.07E+01
10*	9.79E+01	5.76E-01	7.15E-10	3.83E-12	3.08E-03	1.32E-02	8.05E-12	1.11E+01
=====								
(90 days)		Mean:	8.99E-09	4.81E-11				
Standard Deviation:			3.19E-09	1.71E-11				
							1.85E-11	1.09E+01
							3.67E-12	1.33E-01

Co-60

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	1.13E-01	8.61E-08	1.22E-10	1.61E-04	1.61E-04	2.49E-12	1.16E+01
2*	2.97E-01	6.06E-01	1.84E-07	2.61E-10	8.58E-04	1.02E-03	9.36E-11	1.00E+01
3*	1.01E+00	8.20E-01	7.35E-08	1.04E-10	1.16E-03	2.18E-03	5.15E-11	1.03E+01
4*	2.02E+00	5.81E-01	3.72E-08	5.27E-11	8.22E-04	3.00E-03	3.23E-11	1.05E+01
5*	3.01E+00	4.56E-01	2.94E-08	4.16E-11	6.45E-04	3.65E-03	3.40E-11	1.05E+01
6*	4.01E+00	4.06E-01	2.61E-08	3.70E-11	5.75E-04	4.22E-03	3.78E-11	1.04E+01
7*	5.01E+00	3.54E-01	2.29E-08	3.24E-11	5.02E-04	4.72E-03	3.73E-11	1.04E+01
8*	1.79E+01	3.03E+00	1.51E-08	2.14E-11	4.29E-03	9.02E-03	3.77E-11	1.04E+01
9*	4.61E+01	3.97E+00	9.08E-09	1.29E-11	5.63E-03	1.46E-02	3.96E-11	1.04E+01
10*	9.79E+01	3.42E+00	4.25E-09	6.02E-12	4.85E-03	1.95E-02	1.99E-11	1.07E+01
=====								
(90 days)		Mean:	4.88E-08	6.91E-11				
Standard Deviation:			1.72E-08	2.44E-11				
							3.86E-11	1.05E+01
							7.38E-12	1.31E-01

TABEL H-5. Radionuclide and stable metal leaching data for James A. FitzPatrick mixed-bed resin waste-form specimen leached in synthetic seawater with pH 6.4. (continued)

Ni-63

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	5.46E-03	4.14E-09	1.72E-10	2.26E-04	2.26E-04	4.92E-12	1.13E+01
2*	2.97E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.01E+00	1.87E-01	1.68E-08	6.95E-10	7.75E-03	NA	2.29E-09	8.64E+00
4*	2.02E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.01E+00	8.06E-02	5.20E-09	2.15E-10	3.34E-03	NA	9.11E-10	9.04E+00
6*	4.01E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.01E+00	5.87E-02	3.79E-09	1.57E-10	2.43E-03	NA	8.75E-10	9.06E+00
8*	1.79E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.79E+01	6.89E-01	8.55E-10	3.54E-11	2.85E-02	NA	6.88E-10	9.16E+00
=====								
(90 days)		Mean:	6.15E-09	2.55E-10			9.54E-10	9.44E+00
		Standard Deviation:	2.75E-09	1.14E-10			3.72E-10	4.75E-01

Zn-65

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	4.54E-04	3.44E-10	8.20E-12	1.08E-05	1.08E-05	1.12E-14	1.39E+01
2*	2.97E-01	1.83E-03	5.57E-10	1.33E-11	4.37E-05	5.45E-05	2.43E-13	1.26E+01
3*	1.01E+00	5.47E-03	4.90E-10	1.17E-11	1.30E-04	1.85E-04	6.48E-13	1.22E+01
4*	2.02E+00	1.05E-03	6.74E-11	1.61E-12	2.50E-05	2.10E-04	3.00E-14	1.35E+01
5*	3.01E+00	1.67E-03	1.08E-10	2.57E-12	3.99E-05	2.50E-04	1.30E-13	1.29E+01
6*	4.01E+00	8.38E-04	5.39E-11	1.29E-12	2.00E-05	2.70E-04	4.55E-14	1.33E+01
7*	5.01E+00	< 1.51E-03	< 9.74E-11	< 2.32E-12	< 3.59E-05	< 3.06E-04	< 1.91E-13	> 1.27E+01
8*	1.79E+01	5.85E-03	2.91E-11	6.93E-13	1.39E-04	< 4.45E-04	3.97E-14	1.34E+01
9*	4.61E+01	3.41E-02	7.78E-11	1.85E-12	8.11E-04	< 1.26E-03	8.23E-13	1.21E+01
10*	9.79E+01	3.27E-02	4.06E-11	9.67E-13	7.79E-04	< 2.04E-03	5.13E-13	1.23E+01
=====								
(90 days)		Mean:	1.87E-10	4.44E-12			2.67E-13	1.29E+01
		Standard Deviation:	6.31E-11	1.50E-12			9.20E-14	2.00E-01

Sb-125

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	< 2.93E-04	< 2.22E-10	< 1.45E-10	< 1.90E-04	< 1.90E-04	< 3.49E-12	> 1.15E+01
2*	2.97E-01	7.26E-04	2.21E-10	1.43E-10	4.72E-04	< 6.63E-04	2.83E-11	1.05E+01
3*	1.01E+00	< 1.21E-03	< 1.09E-10	< 7.07E-11	< 7.89E-04	< 1.45E-03	< 2.38E-11	> 1.06E+01
4*	2.02E+00	< 5.33E-04	< 3.42E-11	< 2.22E-11	< 3.46E-04	< 1.80E-03	< 5.73E-12	> 1.12E+01
5*	3.01E+00	< 6.83E-04	< 4.40E-11	< 2.86E-11	< 4.44E-04	< 2.24E-03	< 1.61E-11	> 1.08E+01
6*	4.01E+00	< 4.52E-04	< 2.91E-11	< 1.89E-11	< 2.94E-04	< 2.54E-03	< 9.88E-12	> 1.10E+01
7*	5.01E+00	< 5.78E-04	< 3.74E-11	< 2.43E-11	< 3.76E-04	< 2.91E-03	< 2.09E-11	> 1.07E+01
8*	1.79E+01	< 1.56E-03	< 7.75E-12	< 5.04E-12	< 1.01E-03	< 3.92E-03	< 2.10E-12	> 1.17E+01
9*	4.61E+01	< 1.18E-03	< 2.70E-12	< 1.76E-12	< 7.70E-04	< 4.69E-03	< 7.41E-13	> 1.21E+01
10*	9.79E+01	< 1.78E-03	< 2.21E-12	< 1.44E-12	< 1.16E-03	< 5.85E-03	< 1.13E-12	> 1.19E+01
=====								
(90 days)		Mean:	< 7.09E-11	< 4.61E-11			< 1.12E-11	> 1.12E+01
		Standard Deviation:	2.69E-11	1.75E-11			3.26E-12	1.81E-01

TABEL H-5. Radionuclide and stable metal leaching data for James A. FitzPatrick mixed-bed resin waste-form specimen leached in synthetic seawater with pH 6.4. (continued)

Cs-134

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	1.32E-02	1.00E-08	7.25E-09	9.56E-03	9.56E-03	8.80E-09	8.06E+00
2*	2.97E-01	9.33E-02	2.83E-08	2.05E-08	6.76E-02	7.71E-02	5.80E-07	6.24E+00
3*	1.01E+00	1.14E-01	1.02E-08	7.42E-09	8.27E-02	1.60E-01	2.61E-07	6.58E+00
4*	2.02E+00	6.51E-02	4.18E-09	3.02E-09	4.71E-02	2.07E-01	1.93E-07	6.71E+00
5*	3.01E+00	4.23E-02	2.73E-09	1.98E-09	3.06E-02	2.38E-01	1.75E-07	6.76E+00
6*	4.01E+00	3.24E-02	2.09E-09	1.51E-09	2.35E-02	2.61E-01	1.61E-07	6.79E+00
7*	5.01E+00	2.95E-02	1.90E-09	1.38E-09	2.13E-02	2.82E-01	1.53E-07	6.82E+00
8*	1.79E+01	2.61E-01	1.30E-09	9.41E-10	1.89E-01	4.72E-01	1.39E-07	6.86E+00
9*	4.61E+01	3.17E-01	7.23E-10	5.24E-10	2.29E-01	7.01E-01	1.54E-07	6.81E+00
10*	9.79E+01	1.87E-01	2.32E-10	1.68E-10	1.35E-01	8.36E-01	1.30E-07	6.89E+00
=====								
(90 days)		Mean:	6.18E-09	4.47E-09			1.95E-07	6.85E+00
Standard Deviation:			2.71E-09	1.96E-09			4.71E-08	1.47E-01

Cs-137

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	2.39E-02	1.82E-08	6.44E-09	8.49E-03	8.49E-03	6.94E-09	8.16E+00
2*	2.97E-01	1.68E-01	5.09E-08	1.80E-08	5.94E-02	6.79E-02	4.49E-07	6.35E+00
3*	1.01E+00	2.05E-01	1.84E-08	6.53E-09	7.28E-02	1.41E-01	2.02E-07	6.69E+00
4*	2.02E+00	1.18E-01	7.58E-09	2.69E-09	4.19E-02	1.83E-01	8.41E-08	7.08E+00
5*	3.01E+00	7.63E-02	4.92E-09	1.75E-09	2.71E-02	2.10E-01	1.33E-07	6.87E+00
6*	4.01E+00	5.77E-02	3.72E-09	1.32E-09	2.05E-02	2.30E-01	1.22E-07	6.91E+00
7*	5.01E+00	5.26E-02	3.40E-09	1.21E-09	1.87E-02	2.49E-01	1.16E-07	6.94E+00
8*	1.79E+01	4.68E-01	2.33E-09	8.26E-10	1.66E-01	4.15E-01	1.02E-07	6.99E+00
9*	4.61E+01	5.65E-01	1.29E-09	4.58E-10	2.00E-01	6.15E-01	1.06E-07	6.97E+00
10*	9.79E+01	3.35E-01	4.16E-10	1.47E-10	1.19E-01	7.34E-01	8.30E-08	7.08E+00
=====								
(90 days)		Mean:	1.11E-08	3.94E-09			1.40E-07	7.00E+00
Standard Deviation:			4.87E-09	1.73E-09			3.75E-08	1.45E-01

Pu-241

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.97E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.01E+00	7.11E-05	6.37E-12	6.62E-13	7.38E-06	NA	2.08E-15	1.47E+01
4*	2.02E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.01E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.01E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.79E+01	NA	NA	NA	NA	NA	NA	NA
=====								
(90 days)		Mean:	NA	NA			NA	NA
Standard Deviation:			NA	NA			NA	NA

TABEL H-5. Radionuclide and stable metal leaching data for James A. FitzPatrick mixed-bed resin waste-form specimen leached in synthetic seawater with pH 6.4. (continued)

Fe

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.97E-01	< 1.34E+02	< 4.08E-05	< 1.19E-10	< 3.92E-04	NA	< 1.95E-11	> 1.07E+01
3*	1.01E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.02E+00	< 1.35E+02	< 8.66E-06	< 2.53E-11	< 3.95E-04	NA	< 7.44E-12	> 1.11E+01
5*	3.01E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.01E+00	< 1.35E+02	< 8.69E-06	< 2.54E-11	< 3.95E-04	NA	< 1.78E-11	> 1.07E+01
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	< 1.33E+02	< 6.60E-07	< 1.93E-12	< 3.88E-04	NA	< 3.08E-13	> 1.25E+01
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.79E+01	< 1.34E+02	< 1.66E-07	< 4.84E-13	< 3.90E-04	NA	< 1.29E-13	> 1.29E+01
=====								
(90 days)		Mean:	< 1.18E-05	< 3.44E-11			< 9.05E-12	> 1.16E+01
		Standard Deviation:	7.48E-06	2.18E-11			4.16E-12	4.60E-01

Ni

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.97E-01	4.83E+01	1.47E-05	8.80E-10	2.90E-03	NA	1.07E-09	8.97E+00
3*	1.01E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.02E+00	< 7.20E+01	< 4.62E-06	< 2.77E-10	< 4.32E-03	NA	< 8.91E-10	> 9.05E+00
5*	3.01E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.01E+00	< 7.20E+01	< 4.64E-06	< 2.78E-10	< 4.32E-03	NA	< 2.13E-09	> 8.67E+00
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	1.82E+02	9.07E-07	5.44E-11	1.09E-02	NA	2.44E-10	9.61E+00
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.79E+01	2.01E+02	2.50E-07	1.50E-11	1.21E-02	NA	1.23E-10	9.91E+00
=====								
(90 days)		Mean:	< 5.02E-06	< 3.01E-10			< 8.91E-10	> 9.24E+00
		Standard Deviation:	2.58E-06	1.55E-10			3.59E-10	2.26E-01

Co

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.97E-01	< 8.95E+01	< 2.72E-05	< 7.38E-10	< 2.43E-03	NA	< 7.51E-10	> 9.12E+00
3*	1.01E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.02E+00	< 9.00E+01	< 5.77E-06	< 1.57E-10	< 2.45E-03	NA	< 2.86E-10	> 9.54E+00
5*	3.01E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.01E+00	< 9.00E+01	< 5.80E-06	< 1.57E-10	< 2.45E-03	NA	< 6.84E-10	> 9.16E+00
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	< 8.85E+01	< 4.40E-07	< 1.20E-11	< 2.40E-03	NA	< 1.18E-11	> 1.09E+01
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.79E+01	< 8.90E+01	< 1.10E-07	< 3.00E-12	< 2.42E-03	NA	< 4.95E-12	> 1.13E+01
=====								
(90 days)		Mean:	< 7.86E-06	< 2.14E-10			< 3.47E-10	> 1.00E+01
		Standard Deviation:	4.98E-06	1.35E-10			1.60E-10	4.60E-01

TABEL H-5. Radionuclide and stable metal leaching data for James A. FitzPatrick mixed-bed resin waste-form specimen leached in synthetic seawater with pH 6.4. (continued)

Cr

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.97E-01	< 1.79E+01	< 5.43E-06	< 1.94E-10	< 6.38E-04	NA	< 5.18E-11	> 1.03E+01
3*	1.01E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.02E+00	< 1.80E+01	< 1.15E-06	< 4.12E-11	< 6.42E-04	NA	< 1.97E-11	> 1.07E+01
5*	3.01E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.01E+00	< 1.80E+01	< 1.16E-06	< 4.13E-11	< 6.42E-04	NA	< 4.72E-11	> 1.03E+01
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	< 1.77E+01	< 8.80E-08	< 3.14E-12	< 6.31E-04	NA	< 8.15E-13	> 1.21E+01
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.79E+01	< 1.78E+01	< 2.21E-08	< 7.88E-13	< 6.35E-04	NA	< 3.41E-13	> 1.25E+01
=====								
(90 days)		Mean:	< 1.57E-06	< 5.61E-11			< 2.40E-11	> 1.12E+01
Standard Deviation:			9.97E-07	3.56E-11			1.10E-11	4.60E-01

TABLE H-6. Radionuclide and stable metal leaching data for baked James A. FitzPatrick mixed-bed resin waste-form specimen leached in deionized water.

Mn-54

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	3.00E-02	2.26E-08	1.27E-10	1.69E-04	1.69E-04	2.74E-12	1.16E+01
2*	2.99E-01	4.36E-02	1.31E-08	7.38E-11	2.45E-04	4.14E-04	7.61E-12	1.11E+01
3*	1.02E+00	1.22E-02	1.09E-09	6.15E-12	6.88E-05	4.83E-04	1.82E-13	1.27E+01
4*	2.02E+00	2.44E-02	1.56E-09	8.79E-12	1.37E-04	6.20E-04	9.07E-13	1.20E+01
5*	3.02E+00	1.33E-02	4.88E-10	2.75E-12	7.51E-05	6.95E-04	1.50E-13	1.28E+01
6*	4.03E+00	3.22E-03	1.18E-10	6.63E-13	1.81E-05	7.14E-04	1.22E-14	1.39E+01
7*	5.02E+00	3.97E-02	1.46E-09	8.23E-12	2.23E-04	9.37E-04	2.42E-12	1.16E+01
8*	1.79E+01	2.86E-02	8.87E-11	4.99E-13	1.61E-04	1.10E-03	2.07E-14	1.37E+01
9*	4.61E+01	4.21E-03	8.61E-12	4.85E-14	2.37E-05	1.12E-03	5.66E-16	1.52E+01
10*	9.79E+01	1.41E-03	1.91E-12	1.08E-14	7.95E-06	1.13E-03	6.40E-17	1.62E+01
11*	1.43E+02	< 9.05E-04	< 1.41E-12	< 7.94E-15	< 5.10E-06	< 1.13E-03	< 5.98E-17	> 1.62E+01
12*	1.71E+02	< 1.05E-03	< 2.63E-12	< 1.48E-14	< 5.90E-06	< 1.14E-03	< 2.72E-16	> 1.56E+01
13*	2.47E+02	5.81E-03	5.36E-12	3.02E-14	3.27E-05	< 1.17E-03	1.50E-15	1.48E+01
Mean:			3.12E-09	1.75E-11			1.08E-12	1.37E+01
Standard Deviation:			1.90E-09	1.07E-11			6.05E-13	5.05E-01

Co-58

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	8.94E-02	6.73E-08	3.73E-10	4.95E-04	4.95E-04	2.36E-11	1.06E+01
2*	2.99E-01	1.70E-01	5.12E-08	2.84E-10	9.44E-04	1.44E-03	1.13E-10	9.95E+00
3*	1.02E+00	2.30E-01	2.05E-08	1.14E-10	1.27E-03	2.71E-03	6.22E-11	1.02E+01
4*	2.02E+00	2.30E-01	1.47E-08	8.15E-11	1.27E-03	3.99E-03	7.79E-11	1.01E+01
5*	3.02E+00	2.02E-01	7.39E-09	4.09E-11	1.12E-03	5.10E-03	3.32E-11	1.05E+01
6*	4.03E+00	1.81E-01	6.64E-09	3.68E-11	1.01E-03	6.11E-03	3.77E-11	1.04E+01
7*	5.02E+00	1.69E-01	6.23E-09	3.45E-11	9.37E-04	7.05E-03	4.27E-11	1.04E+01
8*	1.79E+01	4.54E-01	1.41E-09	7.79E-12	2.51E-03	9.56E-03	5.05E-12	1.13E+01
9*	4.61E+01	4.83E-01	9.88E-10	5.47E-12	2.68E-03	1.22E-02	7.23E-12	1.11E+01
10*	9.79E+01	5.52E-01	7.47E-10	4.14E-12	3.06E-03	1.53E-02	9.48E-12	1.10E+01
11*	1.43E+02	4.37E-01	6.81E-10	3.78E-12	2.42E-03	1.77E-02	1.35E-11	1.09E+01
12*	1.71E+02	2.76E-01	6.92E-10	3.83E-12	1.53E-03	1.93E-02	1.83E-11	1.07E+01
13*	2.47E+02	5.37E-01	4.96E-10	2.75E-12	2.98E-03	2.22E-02	1.24E-11	1.09E+01
Mean:			1.38E-08	7.63E-11			3.51E-11	1.06E+01
Standard Deviation:			5.92E-09	3.28E-11			8.91E-12	1.15E-01

TABLE H-6. Radionuclide and stable metal leaching data for baked James A. FitzPatrick mixed-bed resin waste-form specimen leached in deionized water. (continued)

Co-60

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	4.82E-01	3.63E-07	5.20E-10	6.91E-04	6.91E-04	4.58E-11	1.03E+01
2*	2.99E-01	9.22E-01	2.77E-07	3.98E-10	1.32E-03	2.01E-03	2.21E-10	9.66E+00
3*	1.02E+00	1.25E+00	1.12E-07	1.60E-10	1.79E-03	3.80E-03	1.23E-10	9.91E+00
4*	2.02E+00	1.23E+00	7.86E-08	1.13E-10	1.76E-03	5.56E-03	1.49E-10	9.83E+00
5*	3.02E+00	1.10E+00	4.04E-08	5.80E-11	1.58E-03	7.15E-03	6.67E-11	1.02E+01
6*	4.03E+00	9.91E-01	3.63E-08	5.20E-11	1.42E-03	8.57E-03	7.52E-11	1.01E+01
7*	5.02E+00	9.15E-01	3.37E-08	4.84E-11	1.31E-03	9.88E-03	8.36E-11	1.01E+01
8*	1.79E+01	2.49E+00	7.71E-09	1.11E-11	3.57E-03	1.34E-02	1.02E-11	1.10E+01
9*	4.61E+01	2.63E+00	5.38E-09	7.71E-12	3.77E-03	1.72E-02	1.43E-11	1.08E+01
10*	9.79E+01	3.00E+00	4.06E-09	5.82E-12	4.29E-03	2.15E-02	1.87E-11	1.07E+01
11*	1.43E+02	2.43E+00	3.79E-09	5.44E-12	3.49E-03	2.50E-02	2.80E-11	1.06E+01
12*	1.71E+02	1.51E+00	3.78E-09	5.42E-12	2.16E-03	2.72E-02	3.64E-11	1.04E+01
13*	2.47E+02	2.40E+00	2.22E-09	3.18E-12	3.44E-03	3.06E-02	1.66E-11	1.08E+01
			Mean:	7.44E-08	1.07E-10		6.83E-11	1.03E+01
			Standard Deviation:	3.20E-08	4.58E-11		1.75E-11	1.17E-01

Ni-63

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	7.93E-02	5.97E-08	2.50E-09	3.32E-03	3.32E-03	1.06E-09	8.97E+00
2*	2.99E-01	4.37E-01	1.31E-07	5.51E-09	1.83E-02	2.16E-02	4.24E-08	7.37E+00
3*	1.02E+00	4.39E-01	3.93E-08	1.65E-09	1.84E-02	4.00E-02	1.30E-08	7.89E+00
4*	2.02E+00	2.90E-01	1.85E-08	7.77E-10	1.21E-02	5.22E-02	7.08E-09	8.15E+00
5*	3.02E+00	2.51E-01	9.20E-09	3.85E-10	1.05E-02	6.27E-02	2.95E-09	8.53E+00
6*	4.03E+00	1.68E-01	6.14E-09	2.57E-10	7.03E-03	6.97E-02	1.84E-09	8.73E+00
7*	5.02E+00	1.55E-01	5.72E-09	2.40E-10	6.51E-03	7.62E-02	2.06E-09	8.69E+00
8*	1.79E+01	3.94E-01	1.22E-09	5.12E-11	1.65E-02	9.28E-02	2.18E-10	9.66E+00
9*	4.61E+01	2.17E-01	4.43E-10	1.86E-11	9.08E-03	1.02E-01	8.30E-11	1.01E+01
10*	9.79E+01	1.44E-01	1.95E-10	8.15E-12	6.02E-03	1.08E-01	3.67E-11	1.04E+01
(90 days)			Mean:	2.72E-08	1.14E-09		7.07E-09	8.85E+00
			Standard Deviation:	1.31E-08	5.50E-10		4.12E-09	3.06E-01

Zn-65

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	8.01E-03	6.03E-09	1.45E-10	1.92E-04	1.92E-04	3.56E-12	1.14E+01
2*	2.99E-01	1.52E-02	4.57E-09	1.10E-10	3.65E-04	5.57E-04	1.68E-11	1.08E+01
3*	1.02E+00	1.03E-02	9.17E-10	2.20E-11	2.46E-04	8.04E-04	2.33E-12	1.16E+01
4*	2.02E+00	1.20E-02	7.65E-10	1.84E-11	2.87E-04	1.09E-03	3.96E-12	1.14E+01
5*	3.02E+00	1.33E-02	4.88E-10	1.17E-11	3.20E-04	1.41E-03	2.73E-12	1.16E+01
6*	4.03E+00	9.54E-03	3.49E-10	8.39E-12	2.29E-04	1.64E-03	1.96E-12	1.17E+01
7*	5.02E+00	1.33E-02	4.89E-10	1.17E-11	3.19E-04	1.96E-03	4.93E-12	1.13E+01
8*	1.79E+01	2.87E-02	8.91E-11	2.14E-12	6.91E-04	2.65E-03	3.81E-13	1.24E+01
9*	4.61E+01	2.79E-02	5.71E-11	1.37E-12	6.71E-04	3.32E-03	4.54E-13	1.23E+01
10*	9.79E+01	2.86E-02	3.87E-11	9.30E-13	6.87E-04	4.01E-03	4.77E-13	1.23E+01
11*	1.43E+02	2.64E-02	4.11E-11	9.88E-13	6.34E-04	4.64E-03	9.25E-13	1.20E+01
12*	1.71E+02	5.17E-03	1.30E-11	3.11E-13	1.24E-04	4.77E-03	1.20E-13	1.29E+01
13*	2.47E+02	1.71E-02	1.58E-11	3.78E-13	4.10E-04	5.18E-03	2.35E-13	1.26E+01
			Mean:	1.07E-09	2.56E-11		2.99E-12	1.19E+01
			Standard Deviation:	5.34E-10	1.28E-11		1.23E-12	1.70E-01

TABLE H-6. Radionuclide and stable metal leaching data for baked James A. FitzPatrick mixed-bed resin waste-form specimen leached in deionized water. (continued)

Sb-125

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	< 1.51E-03	< 1.14E-09	< 7.47E-10	< 9.92E-04	< 9.92E-04	< 9.45E-11	> 1.00E+01
2*	2.99E-01	9.53E-04	2.87E-10	1.89E-10	6.27E-04	< 1.62E-03	4.97E-11	1.03E+01
3*	1.02E+00	< 1.45E-03	< 1.30E-10	< 8.54E-11	< 9.55E-04	< 2.57E-03	< 3.50E-11	> 1.05E+01
4*	2.02E+00	< 1.59E-03	< 1.02E-10	< 6.69E-11	< 1.05E-03	< 3.62E-03	< 5.26E-11	> 1.03E+01
5*	3.02E+00	9.92E-04	3.63E-11	2.39E-11	6.52E-04	< 4.27E-03	1.13E-11	1.09E+01
6*	4.03E+00	< 7.74E-04	< 2.83E-11	< 1.86E-11	< 5.09E-04	< 4.78E-03	< 9.67E-12	> 1.10E+01
7*	5.02E+00	9.38E-04	3.46E-11	2.27E-11	6.17E-04	< 5.40E-03	1.85E-11	1.07E+01
8*	1.79E+01	1.55E-03	4.81E-12	3.16E-12	1.02E-03	< 6.42E-03	8.33E-13	1.21E+01
9*	4.61E+01	< 1.08E-03	< 2.20E-12	< 1.45E-12	< 7.09E-04	< 7.13E-03	< 5.07E-13	> 1.23E+01
10*	9.79E+01	< 1.05E-03	< 1.43E-12	< 9.38E-13	< 6.93E-04	< 7.82E-03	< 4.86E-13	> 1.23E+01
11*	1.43E+02	7.41E-04	1.15E-12	7.60E-13	4.87E-04	< 8.31E-03	5.46E-13	1.23E+01
12*	1.71E+02	1.10E-03	2.76E-12	1.82E-12	7.26E-04	< 9.03E-03	4.11E-12	1.14E+01
13*	2.47E+02	< 1.26E-03	< 1.17E-12	< 7.68E-13	< 8.32E-04	< 9.87E-03	< 9.69E-13	> 1.20E+01
=====								
		Mean:	< 1.36E-10	< 8.94E-11				
		Standard Deviation:	8.63E-11	5.68E-11				
							< 2.14E-11	> 1.12E+01
							8.01E-12	2.39E-01

Cs-134

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	7.83E-02	5.90E-08	4.40E-08	5.84E-02	5.84E-02	3.27E-07	6.48E+00
2*	2.99E-01	1.44E-01	4.32E-08	3.22E-08	1.07E-01	1.65E-01	1.45E-06	5.84E+00
3*	1.02E+00	1.81E-01	1.62E-08	1.21E-08	1.35E-01	3.00E-01	8.68E-07	6.06E+00
4*	2.02E+00	1.42E-01	9.06E-09	6.75E-09	1.06E-01	4.06E-01	8.72E-07	6.06E+00
5*	3.02E+00	9.26E-02	3.39E-09	2.53E-09	6.90E-02	4.75E-01	8.40E-07	6.08E+00
6*	4.03E+00	6.62E-02	2.42E-09	1.80E-09	4.93E-02	5.24E-01	8.14E-07	6.09E+00
7*	5.02E+00	4.47E-02	1.65E-09	1.23E-09	3.33E-02	5.58E-01	7.61E-07	6.12E+00
8*	1.79E+01	9.87E-02	3.06E-10	2.28E-10	7.35E-02	6.31E-01	2.96E-07	6.53E+00
9*	4.61E+01	7.28E-02	1.49E-10	1.11E-10	5.43E-02	6.85E-01	1.44E-07	6.84E+00
10*	9.79E+01	5.06E-02	6.85E-11	5.10E-11	3.77E-02	7.23E-01	7.98E-08	7.10E+00
11*	1.43E+02	2.76E-02	4.31E-11	3.21E-11	2.06E-02	7.44E-01	6.21E-08	7.21E+00
12*	1.71E+02	1.29E-02	3.22E-11	2.40E-11	9.58E-03	7.53E-01	5.24E-08	7.28E+00
13*	2.47E+02	1.25E-02	1.15E-11	8.60E-12	9.32E-03	7.63E-01	3.78E-08	7.42E+00
=====								
		Mean:	1.04E-08	7.77E-09				
		Standard Deviation:	5.25E-09	3.91E-09				
							5.08E-07	6.55E+00
							1.25E-07	1.55E-01

TABLE H-6. Radionuclide and stable metal leaching data for baked James A. FitzPatrick mixed-bed resin waste-form specimen leached in deionized water. (continued)

Cs-137

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	1.42E-01	1.07E-07	3.84E-08	5.09E-02	5.09E-02	2.50E-07	6.60E+00
2*	2.99E-01	2.66E-01	8.00E-08	2.87E-08	9.55E-02	1.46E-01	1.15E-06	5.94E+00
3*	1.02E+00	3.39E-01	3.03E-08	1.09E-08	1.22E-01	2.68E-01	6.58E-07	6.18E+00
4*	2.02E+00	2.56E-01	1.64E-08	5.88E-09	9.19E-02	3.60E-01	6.60E-07	6.18E+00
5*	3.02E+00	1.66E-01	6.09E-09	2.19E-09	5.98E-02	4.20E-01	6.31E-07	6.20E+00
6*	4.03E+00	1.19E-01	4.36E-09	1.57E-09	4.28E-02	4.63E-01	6.02E-07	6.22E+00
7*	5.02E+00	8.05E-02	2.97E-09	1.07E-09	2.89E-02	4.91E-01	5.55E-07	6.26E+00
8*	1.79E+01	1.76E-01	5.44E-10	1.95E-10	6.31E-02	5.55E-01	2.11E-07	6.68E+00
9*	4.61E+01	1.31E-01	2.68E-10	9.62E-11	4.71E-02	6.02E-01	1.01E-07	6.99E+00
10*	9.79E+01	8.98E-02	1.22E-10	4.37E-11	3.22E-02	6.34E-01	5.50E-08	7.26E+00
11*	1.43E+02	4.26E-02	6.64E-11	2.39E-11	1.53E-02	6.49E-01	4.01E-08	7.40E+00
12*	1.71E+02	2.35E-02	5.88E-11	2.11E-11	8.44E-03	6.58E-01	3.47E-08	7.46E+00
13*	2.47E+02	2.30E-02	2.12E-11	7.63E-12	8.26E-03	6.66E-01	2.50E-08	7.60E+00
Mean:			1.91E-08	6.85E-09			3.83E-07	6.69E+00
Standard Deviation:			9.59E-09	3.44E-09			9.76E-08	1.62E-01

Pu-241

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.99E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.02E+00	7.72E-05	6.91E-12	7.26E-13	8.11E-06	NA	2.53E-15	1.46E+01
4*	2.02E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.02E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.03E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.02E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.79E+01	NA	NA	NA	NA	NA	NA	NA
(90 days) Mean:			NA	NA			NA	NA
Standard Deviation:			NA	NA			NA	NA

Fe

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.99E-01	< 1.34E+02	< 4.04E-05	< 1.19E-10	< 3.97E-04	NA	< 1.99E-11	> 1.07E+01
3*	1.02E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.02E+00	6.93E+01	4.43E-06	1.31E-11	2.05E-04	NA	2.02E-12	1.17E+01
5*	3.02E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.03E+00	4.83E+01	1.77E-06	5.23E-12	1.43E-04	NA	7.62E-13	1.21E+01
7*	5.02E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	3.26E+01	1.01E-07	2.98E-13	9.63E-05	NA	7.41E-15	1.41E+01
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.79E+01	< 1.36E+02	< 1.84E-07	< 5.44E-13	< 4.02E-04	NA	< 1.63E-13	> 1.28E+01
(90 days) Mean:			9.37E-06	2.77E-11			4.58E-12	1.23E+01
Standard Deviation:			7.79E-06	2.31E-11			3.86E-12	5.72E-01

TABLE H-6. Radionuclide and stable metal leaching data for baked James A. FitzPatrick mixed-bed resin waste-form specimen leached in deionized water. (continued)

Ni

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.99E-01	8.32E+01	2.50E-05	1.52E-09	5.05E-03	NA	3.23E-09	8.49E+00
3*	1.02E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.02E+00	1.38E+02	8.81E-06	5.34E-10	8.36E-03	NA	3.35E-09	8.47E+00
5*	3.02E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.03E+00	8.52E+01	3.12E-06	1.89E-10	5.17E-03	NA	9.97E-10	9.00E+00
7*	5.02E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	9.29E+01	2.88E-07	1.75E-11	5.64E-03	NA	2.54E-11	1.06E+01
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.79E+01	6.12E+01	8.28E-08	5.03E-12	3.71E-03	NA	1.40E-11	1.09E+01
=====								
(90 days)		Mean:	7.47E-06	4.53E-10			1.52E-09	9.48E+00
Standard Deviation:			4.67E-06	2.83E-10			7.43E-10	5.17E-01

Co

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.99E-01	< 8.95E+01	< 2.69E-05	< 7.40E-10	< 2.46E-03	NA	< 7.66E-10	> 9.12E+00
3*	1.02E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.02E+00	< 9.00E+01	< 5.76E-06	< 1.58E-10	< 2.47E-03	NA	< 2.94E-10	> 9.53E+00
5*	3.02E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.03E+00	< 8.95E+01	< 3.28E-06	< 9.01E-11	< 2.46E-03	NA	< 2.26E-10	> 9.65E+00
7*	5.02E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	< 8.80E+01	< 2.73E-07	< 7.50E-12	< 2.42E-03	NA	< 4.68E-12	> 1.13E+01
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.79E+01	< 9.05E+01	< 1.23E-07	< 3.37E-12	< 2.49E-03	NA	< 6.27E-12	> 1.12E+01
=====								
(90 days)		Mean:	< 7.27E-06	< 2.00E-10			< 2.59E-10	> 1.02E+01
Standard Deviation:			5.02E-06	1.38E-10			1.39E-10	4.59E-01

Cr

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.99E-01	< 1.79E+01	< 5.39E-06	< 1.94E-10	< 6.46E-04	NA	< 5.28E-11	> 1.03E+01
3*	1.02E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.02E+00	< 1.80E+01	< 1.15E-06	< 4.16E-11	< 6.50E-04	NA	< 2.03E-11	> 1.07E+01
5*	3.02E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.03E+00	< 1.79E+01	< 6.55E-07	< 2.37E-11	< 6.46E-04	NA	< 1.56E-11	> 1.08E+01
7*	5.02E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	< 1.76E+01	< 5.45E-08	< 1.97E-12	< 6.35E-04	NA	< 3.22E-13	> 1.25E+01
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.79E+01	< 1.81E+01	< 2.45E-08	< 8.85E-13	< 6.53E-04	NA	< 4.32E-13	> 1.24E+01
=====								
(90 days)		Mean:	< 1.45E-06	< 5.25E-11			< 1.79E-11	> 1.13E+01
Standard Deviation:			1.00E-06	3.63E-11			9.60E-12	4.59E-01

TABLE H-7. Radionuclide and stable metal leaching data for baked James A. FitzPatrick mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with pH 4.2.

Mn-54

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	3.43E-02	2.59E-08	1.45E-10	1.92E-04	1.92E-04	3.60E-12	1.14E+01
2*	2.94E-01	6.01E-02	1.83E-08	1.03E-10	3.37E-04	5.29E-04	1.48E-11	1.08E+01
3*	1.01E+00	8.34E-03	7.43E-10	4.16E-12	4.67E-05	5.76E-04	8.38E-14	1.31E+01
4*	2.02E+00	3.93E-03	2.49E-10	1.40E-12	2.20E-05	5.98E-04	2.32E-14	1.36E+01
5*	3.02E+00	9.23E-03	3.30E-10	1.85E-12	5.17E-05	6.49E-04	6.88E-14	1.32E+01
6*	4.02E+00	8.62E-04	3.09E-11	1.73E-13	4.83E-06	6.54E-04	8.44E-16	1.51E+01
7*	5.01E+00	1.09E-02	3.94E-10	2.21E-12	6.13E-05	7.15E-04	1.77E-13	1.28E+01
8*	1.79E+01	1.26E-01	3.48E-10	1.95E-12	7.05E-04	1.42E-03	3.21E-13	1.25E+01
9*	4.61E+01	3.94E-02	5.95E-11	3.33E-13	2.20E-04	1.64E-03	2.72E-14	1.36E+01
10*	9.79E+01	2.70E-02	2.87E-11	1.61E-13	1.51E-04	1.79E-03	1.45E-14	1.38E+01
=====								
(90 days)		Mean:	4.64E-09	2.60E-11			1.91E-12	1.30E+01
Standard Deviation:			2.96E-09	1.66E-11			1.47E-12	3.83E-01

Co-58

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	6.65E-02	5.01E-08	2.76E-10	3.66E-04	3.66E-04	1.31E-11	1.09E+01
2*	2.94E-01	1.46E-01	4.46E-08	2.46E-10	8.06E-04	1.17E-03	8.47E-11	1.01E+01
3*	1.01E+00	1.54E-01	1.37E-08	7.56E-11	8.49E-04	2.02E-03	2.76E-11	1.06E+01
4*	2.02E+00	2.04E-01	1.30E-08	7.15E-11	1.13E-03	3.15E-03	6.09E-11	1.02E+01
5*	3.02E+00	1.31E-01	4.67E-09	2.57E-11	7.20E-04	3.87E-03	1.33E-11	1.09E+01
6*	4.02E+00	1.20E-01	4.29E-09	2.37E-11	6.61E-04	4.53E-03	1.58E-11	1.08E+01
7*	5.01E+00	1.31E-01	4.72E-09	2.60E-11	7.22E-04	5.25E-03	2.46E-11	1.06E+01
8*	1.79E+01	4.86E-01	1.34E-09	7.40E-12	2.68E-03	7.93E-03	4.63E-12	1.13E+01
9*	4.61E+01	4.74E-01	7.16E-10	3.95E-12	2.61E-03	1.05E-02	3.83E-12	1.14E+01
10*	9.79E+01	5.17E-01	5.50E-10	3.03E-12	2.85E-03	1.34E-02	5.17E-12	1.13E+01
=====								
(90 days)		Mean:	1.38E-08	7.59E-11			2.54E-11	1.08E+01
Standard Deviation:			5.80E-09	3.20E-11			8.48E-12	1.45E-01

Co-60

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	3.53E-01	2.66E-07	3.80E-10	5.04E-04	5.04E-04	2.47E-11	1.06E+01
2*	2.94E-01	7.75E-01	2.36E-07	3.36E-10	1.10E-03	1.61E-03	1.59E-10	9.80E+00
3*	1.01E+00	8.30E-01	7.39E-08	1.05E-10	1.18E-03	2.79E-03	5.38E-11	1.03E+01
4*	2.02E+00	1.12E+00	7.10E-08	1.01E-10	1.59E-03	4.39E-03	1.22E-10	9.91E+00
5*	3.02E+00	7.08E-01	2.53E-08	3.61E-11	1.01E-03	5.40E-03	2.62E-11	1.06E+01
6*	4.02E+00	6.60E-01	2.36E-08	3.37E-11	9.40E-04	6.34E-03	3.20E-11	1.05E+01
7*	5.01E+00	7.06E-01	2.54E-08	3.63E-11	1.01E-03	7.34E-03	4.78E-11	1.03E+01
8*	1.79E+01	2.64E+00	7.28E-09	1.04E-11	3.76E-03	1.11E-02	9.12E-12	1.10E+01
9*	4.61E+01	2.58E+00	3.89E-09	5.55E-12	3.67E-03	1.48E-02	7.57E-12	1.11E+01
10*	9.79E+01	2.81E+00	2.99E-09	4.26E-12	4.00E-03	1.88E-02	1.02E-11	1.10E+01
=====								
(90 days)		Mean:	7.36E-08	1.05E-10			4.92E-11	1.05E+01
Standard Deviation:			3.07E-08	4.38E-11			1.62E-11	1.44E-01

TABLE H-7. Radionuclide and stable metal leaching data for baked James A. FitzPatrick mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with pH 4.2. (continued)

Ni-63

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	4.42E-02	3.34E-08	1.39E-09	1.84E-03	1.84E-03	3.31E-10	9.48E+00
2*	2.94E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.01E+00	3.85E-01	3.43E-08	1.43E-09	1.61E-02	NA	9.89E-09	8.00E+00
4*	2.02E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.02E+00	2.92E-01	1.04E-08	4.35E-10	1.22E-02	NA	3.80E-09	8.42E+00
6*	4.02E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.01E+00	1.29E-01	4.66E-09	1.94E-10	5.39E-03	NA	1.37E-09	8.86E+00
8*	1.79E+01	2.89E-01	7.97E-10	3.32E-11	1.20E-02	NA	9.34E-11	1.00E+01
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.79E+01	1.84E-01	1.96E-10	8.17E-12	7.68E-03	NA	3.76E-11	1.04E+01
=====								
(90 days)		Mean:	1.40E-08	5.82E-10			2.59E-09	9.20E+00
Standard Deviation:			6.46E-09	2.69E-10			1.57E-09	3.84E-01

Zn-65

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	1.38E-02	1.04E-08	2.49E-10	3.30E-04	3.30E-04	1.06E-11	1.10E+01
2*	2.94E-01	2.88E-02	8.76E-09	2.10E-10	6.90E-04	1.02E-03	6.19E-11	1.02E+01
3*	1.01E+00	1.16E-02	1.03E-09	2.47E-11	2.77E-04	1.30E-03	2.95E-12	1.15E+01
4*	2.02E+00	1.26E-02	7.98E-10	1.91E-11	3.01E-04	1.60E-03	4.36E-12	1.14E+01
5*	3.02E+00	1.41E-02	5.04E-10	1.21E-11	3.38E-04	1.94E-03	2.94E-12	1.15E+01
6*	4.02E+00	7.27E-03	2.60E-10	6.24E-12	1.74E-04	2.11E-03	1.10E-12	1.20E+01
7*	5.01E+00	1.77E-02	6.37E-10	1.53E-11	4.24E-04	2.53E-03	8.46E-12	1.11E+01
8*	1.79E+01	1.97E-01	5.45E-10	1.31E-11	4.73E-03	7.27E-03	1.45E-11	1.08E+01
9*	4.61E+01	8.94E-02	1.35E-10	3.24E-12	2.14E-03	9.41E-03	2.57E-12	1.16E+01
10*	9.79E+01	7.87E-02	8.37E-11	2.01E-12	1.89E-03	1.13E-02	2.27E-12	1.16E+01
=====								
(90 days)		Mean:	2.31E-09	5.54E-11			1.12E-11	1.13E+01
Standard Deviation:			1.22E-09	2.92E-11			5.80E-12	1.60E-01

Sb-125

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	8.75E-04	6.60E-10	4.32E-10	5.73E-04	5.73E-04	3.19E-11	1.05E+01
2*	2.94E-01	1.52E-03	4.62E-10	3.02E-10	9.92E-04	1.56E-03	1.28E-10	9.89E+00
3*	1.01E+00	7.29E-04	6.49E-11	4.24E-11	4.77E-04	2.04E-03	8.73E-12	1.11E+01
4*	2.02E+00	< 7.17E-04	< 4.55E-11	< 2.98E-11	< 4.69E-04	< 2.51E-03	< 1.05E-11	> 1.10E+01
5*	3.02E+00	8.47E-04	3.03E-11	1.98E-11	5.54E-04	< 3.06E-03	7.91E-12	1.11E+01
6*	4.02E+00	< 1.12E-03	< 4.02E-11	< 2.63E-11	< 7.35E-04	< 3.80E-03	< 1.96E-11	> 1.07E+01
7*	5.01E+00	< 9.86E-04	< 3.55E-11	< 2.32E-11	< 6.45E-04	< 4.44E-03	< 1.96E-11	> 1.07E+01
8*	1.79E+01	< 3.25E-03	< 8.98E-12	< 5.88E-12	< 2.13E-03	< 6.57E-03	< 2.92E-12	> 1.15E+01
9*	4.61E+01	< 3.06E-03	< 4.62E-12	< 3.02E-12	< 2.00E-03	< 8.57E-03	< 2.24E-12	> 1.16E+01
10*	9.79E+01	< 1.39E-03	< 1.48E-12	< 9.67E-13	< 9.09E-04	< 9.48E-03	< 5.25E-13	> 1.23E+01
=====								
(90 days)		Mean:	< 1.35E-10	< 8.85E-11			< 2.32E-11	> 1.10E+01
Standard Deviation:			7.27E-11	4.76E-11			1.21E-11	2.11E-01

TABLE H-7. Radionuclide and stable metal leaching data for baked James A. FitzPatrick mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with pH 4.2. (continued)

Cs-134

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	4.04E-02	3.04E-08	2.22E-08	2.94E-02	2.94E-02	8.41E-08	7.08E+00
2*	2.94E-01	7.48E-02	2.28E-08	1.66E-08	5.45E-02	8.39E-02	3.87E-07	6.41E+00
3*	1.01E+00	1.32E-01	1.18E-08	8.59E-09	9.65E-02	1.80E-01	3.58E-07	6.45E+00
4*	2.02E+00	1.67E-01	1.06E-08	7.71E-09	1.21E-01	3.02E-01	5.00E-07	6.30E+00
5*	3.02E+00	8.67E-02	3.10E-09	2.26E-09	6.32E-02	3.65E-01	4.57E-07	6.34E+00
6*	4.02E+00	7.04E-02	2.52E-09	1.83E-09	5.13E-02	4.16E-01	4.63E-07	6.33E+00
7*	5.01E+00	5.43E-02	1.96E-09	1.42E-09	3.95E-02	4.56E-01	4.61E-07	6.34E+00
8*	1.79E+01	1.33E-01	3.68E-10	2.68E-10	9.69E-02	5.53E-01	2.08E-07	6.68E+00
9*	4.61E+01	9.32E-02	1.41E-10	1.03E-10	6.79E-02	6.21E-01	1.10E-07	6.96E+00
10*	9.79E+01	5.89E-04	6.27E-13	4.56E-13	4.29E-04	6.21E-01	5.19E-08	7.28E+00
=====								
(90 days)		Mean:	8.37E-09	6.10E-09			3.08E-07	6.62E+00
Standard Deviation:			3.36E-09	2.45E-09			5.58E-08	1.15E-01

Cs-137

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	7.27E-02	5.48E-08	1.96E-08	2.60E-02	2.60E-02	6.56E-08	7.18E+00
2*	2.94E-01	1.34E-01	4.08E-08	1.46E-08	4.79E-02	7.38E-02	2.98E-07	6.53E+00
3*	1.01E+00	2.38E-01	2.12E-08	7.58E-09	8.51E-02	1.59E-01	2.78E-07	6.56E+00
4*	2.02E+00	2.99E-01	1.90E-08	6.78E-09	1.07E-01	2.66E-01	3.32E-07	6.48E+00
5*	3.02E+00	1.56E-01	5.57E-09	1.99E-09	5.56E-02	3.21E-01	3.41E-07	6.47E+00
6*	4.02E+00	1.26E-01	4.52E-09	1.61E-09	4.51E-02	3.66E-01	3.44E-07	6.46E+00
7*	5.01E+00	9.92E-02	3.57E-09	1.28E-09	3.54E-02	4.02E-01	3.40E-07	6.47E+00
8*	1.79E+01	2.40E-01	6.62E-10	2.37E-10	8.56E-02	4.87E-01	1.52E-07	6.82E+00
9*	4.61E+01	1.67E-01	2.53E-10	9.03E-11	5.97E-02	5.47E-01	7.83E-08	7.11E+00
10*	9.79E+01	1.06E-01	1.12E-10	4.02E-11	3.78E-02	5.85E-01	4.42E-08	7.35E+00
=====								
(90 days)		Mean:	1.51E-08	5.38E-09			2.28E-07	6.74E+00
Standard Deviation:			6.04E-09	2.16E-09			4.02E-08	1.10E-01

Pu-241

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (uCi)	RELEASE RATE (uCi/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.94E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.01E+00	3.04E-05	2.71E-12	2.83E-13	3.18E-06	NA	3.88E-16	1.54E+01
4*	2.02E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.02E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.02E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.79E+01	NA	NA	NA	NA	NA	NA	NA
=====								
(90 days)		Mean:	NA	NA			NA	NA
Standard Deviation:			NA	NA			NA	NA

TABLE H-7. Radionuclide and stable metal leaching data for baked James A. FitzPatrick mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with pH 4.2. (continued)

Fe

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.94E-01	< 1.32E+02	< 4.01E-05	< 1.18E-10	< 3.87E-04	NA	< 1.95E-11	> 1.07E+01
3*	1.01E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.02E+00	8.56E+01	5.44E-06	1.60E-11	2.52E-04	NA	3.04E-12	1.15E+01
5*	3.02E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.02E+00	< 1.34E+02	< 4.81E-06	< 1.41E-11	< 3.95E-04	NA	< 5.65E-12	> 1.12E+01
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	1.00E+02	2.77E-07	8.16E-13	2.95E-04	NA	5.63E-14	1.32E+01
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.79E+01	< 6.44E+01	< 6.86E-08	< 2.02E-13	< 1.90E-04	NA	< 2.29E-14	> 1.36E+01
=====								
(90 days)		Mean:	< 1.01E-05	< 2.98E-11			< 5.66E-12	> 1.21E+01
Standard Deviation:			7.58E-06	2.23E-11			3.63E-12	5.78E-01

Ni

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.94E-01	2.78E+01	8.46E-06	5.10E-10	1.68E-03	NA	3.66E-10	9.44E+00
3*	1.01E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.02E+00	1.05E+02	6.69E-06	4.04E-10	6.36E-03	NA	1.94E-09	8.71E+00
5*	3.02E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.02E+00	3.51E+01	1.26E-06	7.58E-11	2.12E-03	NA	1.62E-10	9.79E+00
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	8.60E+01	2.38E-07	1.43E-11	5.19E-03	NA	1.74E-11	1.08E+01
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.79E+01	3.47E+01	3.69E-08	2.23E-12	2.10E-03	NA	2.79E-12	1.16E+01
=====								
(90 days)		Mean:	3.34E-06	2.01E-10			4.97E-10	1.01E+01
Standard Deviation:			1.76E-06	1.06E-10			3.66E-10	5.00E-01

Co

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.94E-01	< 8.90E+01	< 2.71E-05	< 7.41E-10	< 2.43E-03	NA	< 7.71E-10	> 9.11E+00
3*	1.01E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.02E+00	< 8.98E+01	< 5.70E-06	< 1.56E-10	< 2.45E-03	NA	< 2.89E-10	> 9.54E+00
5*	3.02E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.02E+00	< 8.95E+01	< 3.20E-06	< 8.76E-11	< 2.45E-03	NA	< 2.17E-10	> 9.66E+00
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	< 8.85E+01	< 2.45E-07	< 6.69E-12	< 2.42E-03	NA	< 3.78E-12	> 1.14E+01
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.79E+01	< 8.95E+01	< 9.52E-08	< 2.60E-12	< 2.45E-03	NA	< 3.81E-12	> 1.14E+01
=====								
(90 days)		Mean:	< 7.27E-06	< 1.99E-10			< 2.57E-10	> 1.02E+01
Standard Deviation:			5.07E-06	1.39E-10			1.41E-10	4.94E-01

TABLE H-7. Radionuclide and stable metal leaching data for baked James A. FitzPatrick mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with pH 4.2. (continued)

Cr

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² /s)	RELEASE RATE (F/cm ² /s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	NA	NA	NA	NA	NA	NA	NA
2*	2.94E-01	< 1.78E+01	< 5.42E-06	< 1.95E-10	< 6.39E-04	< NA	< 5.32E-11	> 1.03E+01
3*	1.01E+00	NA	NA	NA	NA	NA	NA	NA
4*	2.02E+00	< 1.79E+01	< 1.14E-06	< 4.09E-11	< 6.44E-04	< NA	< 1.99E-11	> 1.07E+01
5*	3.02E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.02E+00	1.15E+01	4.10E-07	1.47E-11	4.11E-04	NA	6.13E-12	> 1.12E+01
7*	5.01E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.79E+01	< 1.77E+01	< 4.89E-08	< 1.76E-12	< 6.35E-04	< NA	< 2.61E-13	> 1.26E+01
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.79E+01	< 1.79E+01	< 1.90E-08	< 6.84E-13	< 6.43E-04	< NA	< 2.63E-13	> 1.26E+01
=====								
(90 days)		Mean:	< 1.41E-06	< 5.05E-11			< 1.59E-11	> 1.15E+01
Standard Deviation:			1.02E-06	3.67E-11			9.97E-12	4.77E-01

APPENDIX I

CHELATING AGENT LEACHING DATA FOR WASTE-FORM SPECIMENS

APPENDIX I

CHELATING AGENT LEACHING DATA FOR WASTE-FORM SPECIMENS

Leaching data of citric and oxalic acids for five Brunswick Unit 1 mixed-bed resin waste-form specimens are given in Tables I-1 through I-5. Similar results of picolinic acid for seven waste-form specimens obtained from James A. FitzPatrick Station are given in Tables I-6 through I-12. The data in Appendix I was derived from data located in Appendix K.

TABLE I-1. Chelating agent leaching data for Brunswick-1 mixed-bed resin waste-form leached in deionized water.

CITRIC

SAMPLE NUMBER	TOTAL TIME (days)	QUANTITY LEACHED (ug)	RELEASE RATE (ug/cm ² *s)	RELEASE RATE (F/cm ² *s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.96E-02	3.29E+03	1.30E-03	2.29E-10	5.80E-04	5.80E-04	1.26E-11	1.09E+01
2*	2.99E-01	2.20E+03	3.71E-04	6.54E-11	3.87E-04	9.66E-04	8.23E-12	1.11E+01
3*	1.01E+00	2.02E+03	1.36E-04	2.39E-11	3.55E-04	1.32E-03	3.69E-12	1.14E+01
4*	2.01E+00	1.98E+03	9.43E-05	1.66E-11	3.49E-04	1.67E-03	4.36E-12	1.14E+01
5*	3.01E+00	4.38E+03	2.85E-04	5.01E-11	7.71E-04	2.44E-03	6.72E-11	1.02E+01
6*	4.01E+00	2.37E+03	1.53E-04	2.70E-11	4.17E-04	2.86E-03	2.75E-11	1.06E+01
7*	5.03E+00	1.35E+03	8.77E-05	1.55E-11	2.38E-04	3.10E-03	1.16E-11	1.09E+01
8*	1.81E+01	1.51E+03	7.70E-06	1.36E-12	2.65E-04	3.36E-03	2.09E-13	1.27E+01
9*	4.60E+01	1.60E+03	3.84E-06	6.77E-13	2.82E-04	3.64E-03	1.50E-13	1.28E+01
10*	9.10E+01	1.90E+03	2.82E-06	4.97E-13	3.34E-04	3.98E-03	1.77E-13	1.28E+01
(90 Days)			Mean:	2.44E-04	4.30E-11		1.36E-11	1.15E+01
Standard Deviation:				1.23E-04	2.17E-11		6.52E-12	3.02E-01

OXALIC

SAMPLE NUMBER	TOTAL TIME (days)	QUANTITY LEACHED (ug)	RELEASE RATE (ug/cm ² *s)	RELEASE RATE (F/cm ² *s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.96E-02	1.75E+03	6.91E-04	2.43E-10	6.14E-04	6.14E-04	1.42E-11	1.08E+01
2*	2.99E-01	2.21E+03	3.73E-04	1.31E-10	7.76E-04	1.39E-03	3.32E-11	1.05E+01
3*	1.01E+00	1.88E+03	1.26E-04	4.44E-11	6.60E-04	2.05E-03	1.27E-11	1.09E+01
4*	2.01E+00	1.59E+03	7.55E-05	2.65E-11	5.57E-04	2.61E-03	1.11E-11	1.10E+01
5*	3.01E+00	1.60E+03	1.04E-04	3.65E-11	5.61E-04	3.17E-03	3.56E-11	1.04E+01
6*	4.01E+00	1.50E+03	9.74E-05	3.42E-11	5.28E-04	3.70E-03	4.40E-11	1.04E+01
7*	5.03E+00	1.62E+03	1.05E-04	3.70E-11	5.70E-04	4.27E-03	6.65E-11	1.02E+01
8*	1.81E+01	1.82E+03	9.31E-06	3.27E-12	6.40E-04	4.91E-03	1.22E-12	1.19E+01
9*	4.60E+01	1.94E+03	4.66E-06	1.64E-12	6.83E-04	5.59E-03	8.81E-13	1.21E+01
10*	9.10E+01	2.10E+03	3.11E-06	1.09E-12	7.37E-04	6.33E-03	8.59E-13	1.21E+01
(90 Days)			Mean:	1.59E-04	5.59E-11		2.20E-11	1.10E+01
Standard Deviation:				6.81E-05	2.39E-11		6.96E-12	2.31E-01

TABLE I-2. Chelating agent leaching data for Brunswick-1 mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with pH 10.4.

CITRIC

SAMPLE NUMBER	TOTAL TIME (days)	QUANTITY LEACHED (ug)	RELEASE RATE (ug/cm ² *s)	RELEASE RATE (F/cm ² *s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	2.79E+03	2.13E-03	4.31E-10	5.64E-04	5.64E-04	3.21E-11	1.05E+01
2*	2.93E-01	2.30E+03	4.06E-04	8.21E-11	4.65E-04	1.03E-03	9.53E-12	1.10E+01
3*	1.00E+00	2.07E+03	1.37E-04	2.78E-11	4.19E-04	1.45E-03	3.75E-12	1.14E+01
4*	2.00E+00	1.89E+03	8.90E-05	1.80E-11	3.83E-04	1.83E-03	3.86E-12	1.14E+01
5*	3.00E+00	1.94E+03	1.15E-04	2.33E-11	3.92E-04	2.22E-03	1.09E-11	1.10E+01
6*	4.00E+00	1.52E+03	9.71E-05	1.96E-11	3.07E-04	2.53E-03	1.10E-11	1.10E+01
7*	5.01E+00	1.23E+03	7.81E-05	1.58E-11	2.49E-04	2.78E-03	9.17E-12	1.10E+01
8*	1.81E+01	1.25E+03	6.10E-06	1.23E-12	2.53E-04	3.03E-03	1.31E-13	1.29E+01
9*	4.60E+01	1.42E+03	3.25E-06	6.57E-13	2.87E-04	3.32E-03	1.07E-13	1.30E+01
10*	9.11E+01	1.55E+03	2.20E-06	4.44E-13	3.14E-04	3.63E-03	1.07E-13	1.30E+01
(90 Days) Mean:			3.06E-04	6.20E-11			8.07E-12	1.16E+01
Standard Deviation:			2.06E-04	4.16E-11			3.02E-12	3.01E-01

OXALIC

SAMPLE NUMBER	TOTAL TIME (days)	QUANTITY LEACHED (ug)	RELEASE RATE (ug/cm ² *s)	RELEASE RATE (F/cm ² *s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE] DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	2.24E+03	1.71E-03	6.88E-10	9.02E-04	9.02E-04	8.20E-11	1.01E+01
2*	2.93E-01	2.43E+03	4.29E-04	1.73E-10	9.82E-04	1.88E-03	4.24E-11	1.04E+01
3*	1.00E+00	1.76E+03	1.17E-04	4.71E-11	7.09E-04	2.59E-03	1.08E-11	1.10E+01
4*	2.00E+00	1.66E+03	7.81E-05	3.15E-11	6.70E-04	3.26E-03	1.18E-11	1.09E+01
5*	3.00E+00	1.63E+03	9.68E-05	3.91E-11	6.58E-04	3.92E-03	3.09E-11	1.05E+01
6*	4.00E+00	1.66E+03	1.06E-04	4.28E-11	6.69E-04	4.59E-03	5.21E-11	1.03E+01
7*	5.01E+00	1.63E+03	1.04E-04	4.18E-11	6.59E-04	5.25E-03	6.41E-11	1.02E+01
8*	1.81E+01	1.67E+03	8.18E-06	3.30E-12	6.75E-04	5.92E-03	9.37E-13	1.20E+01
9*	4.60E+01	1.88E+03	4.32E-06	1.74E-12	7.60E-04	6.68E-03	7.56E-13	1.21E+01
10*	9.11E+01	1.67E+03	2.37E-06	9.56E-13	6.75E-04	7.36E-03	4.97E-13	1.23E+01
(90 Days) Mean:			2.65E-04	1.07E-10			2.96E-11	1.10E+01
Standard Deviation:			1.65E-04	6.65E-11			9.30E-12	2.72E-01

TABLE I-3. Chelating agent leaching data for Brunswick-1 mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with pH 4.2.

CITRIC

SAMPLE NUMBER	TOTAL TIME (days)	TOTAL LEACHED (ug)	RELEASE RATE (ug/cm ² *s)	RELEASE RATE (F/cm ² *s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	6.44E+03	4.33E-03	8.12E-10	1.21E-03	1.21E-03	1.32E-10	9.88E+00
2*	2.92E-01	5.19E+03	8.28E-04	1.55E-10	9.73E-04	2.18E-03	3.96E-11	1.04E+01
3*	1.00E+00	2.84E+03	1.56E-04	2.92E-11	5.32E-04	2.71E-03	4.81E-12	1.13E+01
4*	2.00E+00	3.51E+03	1.36E-04	2.56E-11	6.59E-04	3.37E-03	9.08E-12	1.10E+01
5*	3.00E+00	3.64E+03	1.41E-04	2.65E-11	6.82E-04	4.05E-03	1.65E-11	1.08E+01
6*	4.00E+00	3.68E+03	1.90E-04	3.57E-11	6.91E-04	4.75E-03	4.22E-11	1.04E+01
7*	5.02E+00	2.39E+03	1.54E-04	2.89E-11	4.48E-04	5.19E-03	3.57E-11	1.04E+01
8*	1.81E+01	4.36E+03	2.23E-05	4.18E-12	8.18E-04	6.01E-03	1.76E-12	1.18E+01
9*	4.60E+01	6.22E+03	1.49E-05	2.80E-12	1.17E-03	7.18E-03	2.26E-12	1.16E+01
10*	9.10E+01	6.40E+03	9.63E-06	1.81E-12	1.20E-03	8.38E-03	2.07E-12	1.17E+01
(90 Days)			Mean:	5.98E-04	1.12E-10		2.86E-11	1.09E+01
Standard Deviation:				4.21E-04	7.90E-11		1.26E-11	2.07E-01

OXALIC

SAMPLE NUMBER	TOTAL TIME (days)	TOTAL LEACHED (ug)	RELEASE RATE (ug/cm ² *s)	RELEASE RATE (F/cm ² *s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	4.48E+03	3.01E-03	1.13E-09	1.68E-03	1.68E-03	2.53E-10	9.60E+00
2*	2.92E-01	3.79E+03	6.05E-04	2.26E-10	1.42E-03	3.09E-03	8.41E-11	1.01E+01
3*	1.00E+00	2.72E+03	1.49E-04	5.58E-11	1.02E-03	4.11E-03	1.76E-11	1.08E+01
4*	2.00E+00	1.94E+03	7.53E-05	2.82E-11	7.25E-04	4.84E-03	1.10E-11	1.10E+01
5*	3.00E+00	1.92E+03	7.45E-05	2.79E-11	7.17E-04	5.55E-03	1.83E-11	1.07E+01
6*	4.00E+00	1.96E+03	1.01E-04	3.79E-11	7.34E-04	6.29E-03	4.76E-11	1.03E+01
7*	5.02E+00	1.68E+03	1.08E-04	4.04E-11	6.27E-04	6.92E-03	6.97E-11	1.02E+01
8*	1.81E+01	1.84E+03	9.42E-06	3.53E-12	6.89E-04	7.60E-03	1.25E-12	1.19E+01
9*	4.60E+01	1.80E+03	4.32E-06	1.62E-12	6.74E-04	8.28E-03	7.56E-13	1.21E+01
10*	9.10E+01	1.82E+03	2.73E-06	1.02E-12	6.81E-04	8.96E-03	6.63E-13	1.22E+01
(90 Days)			Mean:	4.14E-04	1.55E-10		5.04E-11	1.09E+01
Standard Deviation:				2.94E-04	1.10E-10		2.44E-11	2.88E-01

TABLE I-4. Chelating agent leaching data for Brunswick-1 mixed-bed resin waste-form specimen leached in synthetic Hanford ground water with pH 8.9.

CITRIC

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² *s)	RELEASE RATE (F/cm ² *s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	6.98E+03	2.84E-03	6.82E-10	1.68E-03	1.68E-03	5.75E-11	1.02E+01
2*	2.94E-01	2.52E+03	4.21E-04	1.01E-10	6.06E-04	2.28E-03	1.03E-11	1.10E+01
3*	1.00E+00	2.12E+03	1.09E-04	2.61E-11	5.09E-04	2.79E-03	2.35E-12	1.16E+01
4*	2.00E+00	1.70E+03	9.90E-05	2.38E-11	4.09E-04	3.20E-03	4.78E-12	1.13E+01
5*	3.00E+00	1.48E+03	9.90E-05	2.38E-11	3.56E-04	3.56E-03	8.12E-12	1.11E+01
6*	4.00E+00	1.42E+03	9.78E-05	2.35E-11	3.41E-04	3.90E-03	1.12E-11	1.10E+01
7*	5.01E+00	1.09E+03	7.46E-05	1.79E-11	2.63E-04	4.16E-03	8.37E-12	1.11E+01
8*	1.81E+01	1.46E+03	7.68E-06	1.85E-12	3.50E-04	4.51E-03	2.08E-13	1.27E+01
9*	4.60E+01	2.42E+03	5.97E-06	1.44E-12	5.81E-04	5.09E-03	3.63E-13	1.24E+01
10*	9.10E+01	6.46E+03	9.89E-06	2.38E-12	1.55E-03	6.64E-03	2.18E-12	1.17E+01
=====								
(90 Days)		Mean:	3.76E-04	9.04E-11			1.05E-11	1.14E+01
Standard Deviation:			2.76E-04	6.64E-11			5.38E-12	2.30E-01

OXALIC

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² *s)	RELEASE RATE (F/cm ² *s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	2.82E+03	1.15E-03	5.49E-10	1.35E-03	1.35E-03	3.73E-11	1.04E+01
2*	2.94E-01	3.23E+03	5.39E-04	2.58E-10	1.55E-03	2.90E-03	6.73E-11	1.02E+01
3*	1.00E+00	2.20E+03	1.13E-04	5.40E-11	1.05E-03	3.95E-03	1.01E-11	1.10E+01
4*	2.00E+00	1.81E+03	1.05E-04	5.06E-11	8.70E-04	4.82E-03	2.16E-11	1.07E+01
5*	3.00E+00	1.65E+03	1.11E-04	5.31E-11	7.93E-04	5.61E-03	4.04E-11	1.04E+01
6*	4.00E+00	1.84E+03	1.27E-04	6.09E-11	8.84E-04	6.50E-03	7.49E-11	1.01E+01
7*	5.01E+00	1.64E+03	1.12E-04	5.37E-11	7.86E-04	7.28E-03	7.50E-11	1.01E+01
8*	1.81E+01	1.99E+03	1.05E-05	5.01E-12	9.52E-04	8.24E-03	1.53E-12	1.18E+01
9*	4.60E+01	2.39E+03	5.89E-06	2.82E-12	1.14E-03	9.38E-03	1.41E-12	1.19E+01
10*	9.10E+01	2.29E+03	3.50E-06	1.68E-12	1.10E-03	1.05E-02	1.09E-12	1.20E+01
=====								
(90 Days)		Mean:	2.27E-04	1.09E-10			3.31E-11	1.09E+01
Standard Deviation:			1.13E-04	5.42E-11			Standard Dev9.68E-12	2.39E-01

TABLE I-5. Chelating agent leaching data for Brunswick mixed-bed resin waste-form specimen leached in synthetic seawater with pH 6.4.

CITRIC

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² *s)	RELEASE RATE (F/cm ² *s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	2.10E+03	1.22E-03	1.94E-10	3.33E-04	3.33E-04	1.06E-11	1.10E+01
2*	2.94E-01	2.72E+03	6.48E-04	1.03E-10	4.32E-04	7.65E-04	2.44E-11	1.06E+01
3*	1.00E+00	1.16E+03	8.12E-05	1.29E-11	1.84E-04	9.49E-04	1.31E-12	1.19E+01
4*	2.00E+00	1.56E+03	7.77E-05	1.23E-11	2.48E-04	1.20E-03	2.94E-12	1.15E+01
5*	3.00E+00	2.64E+03	1.31E-04	2.08E-11	4.19E-04	1.62E-03	1.42E-11	1.08E+01
6*	4.00E+00	2.08E+03	1.03E-04	1.64E-11	3.30E-04	1.95E-03	1.24E-11	1.09E+01
7*	5.02E+00	1.53E+03	7.48E-05	1.19E-11	2.43E-04	2.19E-03	8.42E-12	1.11E+01
8*	1.81E+01	3.14E+03	1.19E-05	1.89E-12	4.98E-04	2.69E-03	5.01E-13	1.23E+01
9*	4.60E+01	1.71E+03	3.04E-06	4.84E-13	2.72E-04	2.96E-03	9.44E-14	1.30E+01
10*	9.10E+01	1.37E+03	1.51E-06	2.40E-13	2.17E-04	3.18E-03	5.07E-14	1.33E+01
(90 Days)		Mean:	2.35E-04	3.73E-11			7.50E-12	1.16E+01
Standard Deviation:			1.25E-04	1.98E-11			2.55E-12	3.01E-01

OXALIC

SAMPLE NUMBER	TOTAL TIME (days)	TOTAL LEACHED (ug)	RELEASE RATE (ug/cm ² *s)	RELEASE RATE (F/cm ² *s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	1.34E+03	7.81E-04	2.47E-10	4.26E-04	4.26E-04	1.73E-11	1.08E+01
2*	2.94E-01	NA	NA	NA	NA	NA	NA	NA
3*	1.00E+00	1.23E+03	8.66E-05	2.74E-11	3.91E-04	NA	5.94E-12	1.12E+01
4*	2.00E+00	NA	NA	NA	NA	NA	NA	NA
5*	3.00E+00	NA	NA	NA	NA	NA	NA	NA
6*	4.00E+00	NA	NA	NA	NA	NA	NA	NA
7*	5.02E+00	NA	NA	NA	NA	NA	NA	NA
8*	1.81E+01	NA	NA	NA	NA	NA	NA	NA
9*	4.60E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.10E+01	NA	NA	NA	NA	NA	NA	NA
(90 Days)		Mean:	4.34E-04	1.37E-10			1.16E-11	1.10E+01
Standard Deviation:			3.47E-04	1.10E-10			5.70E-12	2.33E-01

TABLE I-6. Chelating agent leaching data for James A. FitzPatrick mixed-bed resin waste-form specimen leached in deionized water.

PICOLINIC

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² *s)	RELEASE RATE (F/cm ² *s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	1.85E+04	1.41E-02	4.55E-09	5.95E-03	5.95E-03	3.39E-09	8.47E+00
2*	2.93E-01	1.11E+05	3.45E-02	1.11E-08	3.58E-02	4.18E-02	1.66E-07	6.78E+00
3*	1.00E+00	2.61E+04	2.38E-03	7.69E-10	8.42E-03	5.02E-02	2.72E-09	8.57E+00
4*	2.00E+00	3.17E+04	2.05E-03	6.62E-10	1.02E-02	6.04E-02	4.95E-09	8.31E+00
5*	3.00E+00	7.61E+04	4.93E-03	1.59E-09	2.45E-02	8.49E-02	4.83E-08	7.32E+00
6*	4.00E+00	8.62E+04	5.59E-03	1.80E-09	2.78E-02	1.13E-01	8.77E-08	7.06E+00
7*	5.00E+00	2.42E+05	1.57E-02	5.05E-09	7.82E-02	1.91E-01	8.85E-07	6.05E+00
8*	1.79E+01	4.85E+05	2.43E-03	7.84E-10	1.56E-01	3.47E-01	6.67E-08	7.18E+00
9*	4.61E+01	3.29E+05	7.57E-04	2.44E-10	1.06E-01	4.53E-01	4.84E-08	7.32E+00
10*	9.80E+01	2.73E+05	3.41E-04	1.10E-10	8.80E-02	5.41E-01	3.57E-08	7.45E+00
11*	1.43E+02	1.27E+05	1.82E-04	5.88E-11	4.08E-02	5.82E-01	2.94E-08	7.53E+00
12*	1.71E+02	3.82E+04	8.85E-05	2.85E-11	1.23E-02	5.95E-01	2.61E-08	7.58E+00
Mean:								6.92E-03
Standard Deviation:								2.93E-03
								2.23E-09
								9.45E-10
								1.17E-07
								7.47E+00
								7.10E-08
								2.08E-01

TABLE I-7. Chelating agent leaching data for James A. FitzPatrick mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with pH 10.4.

PICOLINIC

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² *s)	RELEASE RATE (F/cm ² *s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.40E-02	2.00E+04	1.55E-02	5.10E-09	6.61E-03	6.61E-03	4.22E-09	8.38E+00
2*	2.93E-01	2.43E+04	7.55E-03	2.49E-09	8.02E-03	1.46E-02	8.26E-09	8.08E+00
3*	1.00E+00	3.29E+05	3.01E-02	9.93E-09	1.09E-01	1.23E-01	4.53E-07	6.34E+00
4*	2.00E+00	2.25E+04	1.46E-03	4.81E-10	7.42E-03	1.31E-01	2.60E-09	8.58E+00
5*	3.00E+00	3.17E+05	2.05E-02	6.75E-09	1.04E-01	2.35E-01	1.70E-07	6.77E+00
6*	4.00E+00	9.52E+04	6.17E-03	2.03E-09	3.14E-02	2.66E-01	1.67E-07	6.78E+00
7*	5.00E+00	3.11E+04	2.02E-03	6.65E-10	1.03E-02	2.77E-01	1.45E-07	6.84E+00
8*	1.79E+01	7.96E+05	3.99E-03	1.31E-09	2.62E-01	5.39E-01	1.92E-07	6.72E+00
9*	4.61E+01	4.95E+05	1.14E-03	3.76E-10	1.63E-01	7.02E-01	1.53E-07	6.81E+00
10*	9.80E+01	1.34E+05	1.68E-04	5.53E-11	4.43E-02	7.46E-01	8.67E-08	7.06E+00
(90 days) Mean:								8.85E-03
Standard Deviation:								2.92E-09
								3.16E-03
								1.04E-09
								1.38E-07
								7.24E+00
								4.22E-08
								2.52E-01

TABLE I-8. Chelating agent leaching data for James A. FitzPatrick mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with pH 4.2.

PICOLINIC

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² *s)	RELEASE RATE (F/cm ² *s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	2.24E+04	1.69E-02	5.48E-09	7.28E-03	7.28E-03	5.10E-09	8.29E+00
2*	2.95E-01	2.87E+04	8.80E-03	2.86E-09	9.33E-03	1.66E-02	1.13E-08	7.95E+00
3*	1.01E+00	2.24E+05	2.01E-02	6.54E-09	7.29E-02	8.95E-02	2.04E-07	6.69E+00
4*	2.01E+00	4.73E+04	3.03E-03	9.85E-10	1.54E-02	1.05E-01	1.14E-08	7.94E+00
5*	3.01E+00	4.58E+04	2.95E-03	9.57E-10	1.49E-02	1.20E-01	1.81E-08	7.74E+00
6*	4.01E+00	1.65E+05	1.06E-02	3.43E-09	5.34E-02	1.73E-01	3.28E-07	6.48E+00
7*	5.01E+00	5.56E+04	3.57E-03	1.16E-09	1.81E-02	1.91E-01	4.83E-08	7.32E+00
8*	1.79E+01	5.42E+04	2.69E-04	8.74E-11	1.76E-02	2.09E-01	2.26E-08	7.65E+00
9*	4.61E+01	4.89E+05	1.11E-03	3.62E-10	1.59E-01	3.67E-01	3.04E-08	7.52E+00
10*	9.80E+01	1.57E+05	1.94E-04	6.30E-11	5.09E-02	4.18E-01	1.93E-08	7.72E+00
=====								
(90 days)		Mean:	6.75E-03	2.19E-09			6.99E-08	7.53E+00
		Standard Deviation:	2.25E-03	7.30E-10			3.42E-08	1.78E-01

TABLE I-9. Chelating agent leaching data for James A. FitzPatrick mixed-bed resin waste-form specimen leached in synthetic Hanford ground water with pH 8.9.

PICOLINIC

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² *s)	RELEASE RATE (F/cm ² *s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.61E-02	1.94E+04	1.44E-02	4.60E-09	6.22E-03	6.22E-03	3.70E-09	8.43E+00
2*	2.97E-01	4.14E+04	1.25E-02	4.02E-09	1.33E-02	1.95E-02	2.30E-08	7.64E+00
3*	1.01E+00	3.40E+04	3.04E-03	9.74E-10	1.09E-02	3.04E-02	4.63E-09	8.33E+00
4*	2.01E+00	2.51E+04	1.60E-03	5.11E-10	8.03E-03	3.84E-02	3.12E-09	8.51E+00
5*	3.01E+00	3.61E+04	2.30E-03	7.36E-10	1.16E-02	5.00E-02	1.09E-08	7.96E+00
6*	4.01E+00	2.34E+04	1.49E-03	4.78E-10	7.50E-03	5.75E-02	6.48E-09	8.19E+00
7*	5.01E+00	1.94E+04	1.23E-03	3.95E-10	6.21E-03	6.37E-02	5.69E-09	8.24E+00
8*	1.79E+01	2.87E+04	1.41E-04	4.53E-11	9.19E-03	7.29E-02	1.75E-10	9.76E+00
9*	4.61E+01	5.66E+05	1.28E-03	4.10E-10	1.81E-01	2.54E-01	1.34E-08	7.87E+00
10*	9.79E+01	6.03E+05	7.41E-04	2.37E-10	1.93E-01	4.47E-01	2.25E-08	7.65E+00
=====								
(90 days)		Mean:	3.87E-03	1.24E-09			9.37E-09	8.26E+00
		Standard Deviation:	1.62E-03	5.19E-10			2.54E-09	1.93E-01

TABLE I-10. Chelating agent leaching data for James A. FitzPatrick mixed-bed resin waste-form specimen leached in synthetic seawater with pH 6.4.

PICOLINIC

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² *s)	RELEASE RATE (F/cm ² *s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	1.49E+04	1.13E-02	3.66E-09	4.82E-03	4.82E-03	2.24E-09	8.65E+00
2*	2.97E-01	2.63E+04	7.99E-03	2.58E-09	8.50E-03	1.33E-02	9.18E-09	8.04E+00
3*	1.01E+00	5.33E+04	4.78E-03	1.54E-09	1.72E-02	3.05E-02	1.13E-08	7.95E+00
4*	2.02E+00	3.20E+04	2.05E-03	6.64E-10	1.04E-02	4.09E-02	5.12E-09	8.29E+00
5*	3.01E+00	2.03E+04	1.31E-03	4.24E-10	6.57E-03	4.75E-02	3.53E-09	8.45E+00
6*	4.01E+00	1.78E+04	1.15E-03	3.71E-10	5.77E-03	5.32E-02	3.80E-09	8.42E+00
7*	5.01E+00	1.89E+04	1.22E-03	3.95E-10	6.11E-03	5.93E-02	5.53E-09	8.26E+00
8*	1.79E+01	1.51E+05	7.50E-04	2.42E-10	4.87E-02	1.08E-01	4.86E-09	8.31E+00
9*	4.61E+01	NA	NA	NA	NA	NA	NA	NA
10*	9.79E+01	NA	NA	NA	NA	NA	NA	NA
Mean:			3.82E-03	1.24E-09			5.70E-09	8.30E+00
Standard Deviation:			1.38E-03	4.47E-10			1.08E-09	7.98E-02

TABLE I-11. Chelating agent leaching data for baked James A. FitzPatrick mixed-bed resin waste-form specimen leached in deionized water.

PICOLINIC

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² *s)	RELEASE RATE (F/cm ² *s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.54E-02	5.82E+04	4.39E-02	1.43E-08	1.90E-02	1.90E-02	3.49E-08	7.46E+00
2*	2.99E-01	3.85E+05	1.16E-01	3.79E-08	1.26E-01	1.45E-01	2.00E-06	5.70E+00
3*	1.02E+00	4.63E+05	4.14E-02	1.35E-08	1.51E-01	2.96E-01	8.80E-07	6.06E+00
4*	2.02E+00	1.20E+05	7.67E-03	2.51E-09	3.92E-02	3.35E-01	4.64E-07	6.33E+00
5*	3.02E+00	3.45E+05	1.26E-02	4.13E-09	1.13E-01	4.48E-01	4.03E-07	6.39E+00
6*	4.03E+00	5.39E+04	1.97E-03	6.45E-10	1.76E-02	4.66E-01	5.86E-07	6.23E+00
7*	5.02E+00	5.71E+04	2.10E-03	6.88E-10	1.87E-02	4.84E-01	5.08E-07	6.29E+00
8*	1.79E+01	4.70E+05	1.46E-03	4.76E-10	1.54E-01	6.38E-01	1.54E-07	6.81E+00
9*	4.61E+01	2.42E+05	4.94E-04	1.62E-10	7.90E-02	7.17E-01	1.23E-07	6.91E+00
10*	9.79E+01	4.60E+05	6.22E-04	2.04E-10	1.50E-01	8.68E-01	8.12E-08	7.09E+00
11*	1.43E+02	3.06E+05	4.77E-04	1.56E-10	1.00E-01	9.68E-01	1.09E-07	6.96E+00
12*	1.71E+02	4.83E+04	1.21E-04	3.96E-11	1.58E-02	9.84E-01	1.84E-07	6.73E+00
Mean:			1.90E-02	6.23E-09			4.61E-07	6.58E+00
Standard Deviation:			9.89E-03	3.24E-09			1.58E-07	1.43E-01

TABLE I-12. Chelating agent leaching data for baked James A. FitzPatrick mixed-bed resin waste-form specimen leached in synthetic Barnwell ground water with pH 4.2.

PICOLINIC

SAMPLE NUMBER	TOTAL TIME (days)	ACTIVITY LEACHED (ug)	RELEASE RATE (ug/cm ² *s)	RELEASE RATE (F/cm ² *s)	INCREMENTAL RELEASE	CUMULATIVE RELEASE	EFFECTIVE DIFFUSIVITY (cm ² /s)	LEACH INDEX
1*	8.47E-02	2.22E+04	1.67E-02	5.45E-09	7.22E-03	7.22E-03	5.08E-09	8.29E+00
2*	2.94E-01	2.28E+04	6.94E-03	2.26E-09	7.41E-03	1.46E-02	7.15E-09	8.15E+00
3*	1.01E+00	3.20E+04	2.85E-03	9.28E-10	1.04E-02	2.51E-02	4.17E-09	8.38E+00
4*	2.02E+00	2.24E+04	1.42E-03	4.63E-10	7.30E-03	3.24E-02	2.55E-09	8.59E+00
5*	3.02E+00	1.57E+05	5.61E-03	1.82E-09	5.10E-02	8.34E-02	6.69E-08	7.17E+00
6*	4.02E+00	8.57E+04	3.07E-03	9.98E-10	2.79E-02	1.11E-01	2.82E-08	7.55E+00
7*	5.01E+00	3.72E+04	1.34E-03	4.36E-10	1.21E-02	1.23E-01	6.92E-09	8.16E+00
8*	1.79E+01	5.68E+04	1.57E-04	5.11E-11	1.85E-02	1.42E-01	2.21E-10	9.66E+00
9*	4.61E+01	7.24E+05	1.09E-03	3.56E-10	2.36E-01	3.77E-01	3.24E-08	7.49E+00
10*	9.79E+01	1.36E+05	1.45E-04	4.72E-11	4.44E-02	4.22E-01	1.96E-08	7.71E+00
=====								
(90 days)		Mean:	3.94E-03	1.28E-09			1.73E-08	8.12E+00
Standard Deviation:			1.59E-03	5.17E-10			6.55E-09	2.23E-01

APPENDIX J

CONCENTRATIONS OF RADIONUCLIDES AND STABLE METALS IN LEACHATES

APPENDIX J

CONCENTRATIONS OF RADIONUCLIDES AND STABLE METALS IN LEACHATES

Concentrations of radionuclides and stable metals in leachates generated during testing of five Brunswick Unit 1 cation resin waste-form specimens are given in Tables J-1 through J-5. Similar results for the leachates generated during testing of five Brunswick Unit 1 mixed-bed resin waste-form specimens are given in Tables J-6 through J-10. Concentrations of radionuclides and stable metals in leachates generated during testing of seven ion-exchange resin waste-form specimens obtained from the James A. FitzPatrick Station are given in Tables J-11 through J-17. The data in Appendix J was used to compute the data in Appendices G and H.

Table J-1. Concentrations of radionuclides and stable metals in Brunswick-1 cation resin waste-form leachates: deionized water (uCi/ml decay corrected to 12/18/87 or ug/ml).

Sample	Mn-54		Fe-55		Co-58		Co-60		Ni-63	
PR *	3.13E-08 +/-	1.41E-08	NA +/-	NA	< 2.83E-07 +/-	8.68E-08	1.15E-07 +/-	1.10E-08	NA +/-	NA
1 *	3.21E-08 +/-	1.31E-08	NA +/-	NA	< 5.45E-07 +/-	2.72E-07	9.23E-08 +/-	8.54E-09	NA +/-	NA
2 *	2.82E-07 +/-	1.97E-08	1.30E-05 +/-	2.40E-07	< 1.34E-06 +/-	3.91E-07	7.99E-07 +/-	1.81E-08	5.36E-07 +/-	8.25E-08
3 *	3.60E-07 +/-	2.78E-08	NA +/-	NA	< 1.17E-06 +/-	5.36E-07	1.45E-06 +/-	3.08E-08	NA +/-	NA
4 *	5.33E-07 +/-	3.84E-08	1.69E-07 +/-	2.65E-08	< 9.83E-07 +/-	4.91E-07	1.95E-06 +/-	3.47E-08	1.12E-07 +/-	1.10E-08
5 *	1.48E-06 +/-	4.37E-08	NA +/-	NA	< 2.03E-06 +/-	6.60E-07	5.24E-06 +/-	5.45E-08	NA +/-	NA
6 *	9.76E-07 +/-	3.61E-08	4.52E-07 +/-	5.34E-08	< 2.41E-06 +/-	7.75E-07	3.12E-06 +/-	4.02E-08	2.56E-06 +/-	3.10E-07
7 *	1.26E-06 +/-	4.82E-08	NA +/-	NA	< 1.50E-06 +/-	7.50E-07	4.51E-06 +/-	4.78E-08	NA +/-	NA
8 *	3.48E-07 +/-	2.50E-08	8.39E-08 +/-	1.07E-08	< 1.38E-06 +/-	5.09E-07	1.41E-06 +/-	2.51E-08	7.31E-08 +/-	7.10E-09
9 *	5.49E-08 +/-	1.76E-08	NA +/-	NA	< 1.16E-06 +/-	4.69E-07	4.59E-07 +/-	1.32E-08	3.28E-06 +/-	3.10E-07
10 *	< 9.63E-08 +/-	1.65E-08	1.29E-06 +/-	1.63E-07	< 1.34E-06 +/-	6.70E-07	3.27E-07 +/-	1.26E-08	4.16E-06 +/-	7.10E-07
11 *	< 3.89E-08 +/-	1.94E-08	NA +/-	NA	< 2.52E-06 +/-	9.04E-07	4.10E-07 +/-	1.44E-08	NA +/-	NA
12 *	< 4.64E-08 +/-	2.32E-08	NA +/-	NA	< 1.82E-06 +/-	9.10E-07	4.90E-07 +/-	1.39E-08	NA +/-	NA
13 *	< 4.30E-08 +/-	2.15E-08	NA +/-	NA	< 3.49E-06 +/-	1.01E-06	6.51E-07 +/-	1.68E-08	NA +/-	NA
14 *	5.16E-08 +/-	2.05E-08	NA +/-	NA	< 2.47E-06 +/-	1.20E-06	2.38E-07 +/-	1.11E-08	NA +/-	NA
15 *	< 3.12E-08 +/-	1.56E-08	NA +/-	NA	< 2.96E-06 +/-	1.39E-06	1.86E-07 +/-	1.06E-08	NA +/-	NA
16 *	1.49E-07 +/-	5.63E-08	NA +/-	NA	ND	ND	2.01E-06 +/-	3.64E-08	NA +/-	NA

Sample	Zn-65		Sr-90		Sb-125		Cs-134		Cs-137	
PR *	< 7.55E-08 +/-	3.48E-08	NA +/-	NA	< 4.76E-08 +/-	4.77E-06	< 1.90E-08 +/-	9.49E-09	< 1.60E-08 +/-	7.99E-09
1 *	< 6.22E-08 +/-	3.11E-08	NA +/-	NA	< 4.66E-08 +/-	2.11E-08	< 2.50E-08 +/-	8.44E-09	3.98E-07 +/-	1.32E-08
2 *	< 1.10E-07 +/-	3.68E-08	2.31E-06 +/-	1.72E-07	< 5.81E-08 +/-	2.03E-08	6.67E-08 +/-	7.04E-09	8.27E-07 +/-	1.83E-08
3 *	< 1.04E-07 +/-	4.53E-08	NA +/-	NA	< 4.70E-08 +/-	2.35E-08	7.41E-08 +/-	8.31E-09	2.36E-06 +/-	5.52E-08
4 *	< 1.54E-07 +/-	5.88E-08	2.17E-08 +/-	2.09E-09	< 7.83E-08 +/-	3.11E-08	9.76E-08 +/-	8.79E-09	2.52E-06 +/-	3.70E-08
5 *	1.84E-07 +/-	7.21E-08	NA +/-	NA	< 8.30E-08 +/-	4.15E-08	9.37E-08 +/-	9.05E-09	2.30E-06 +/-	4.20E-08
6 *	< 2.05E-07 +/-	5.81E-08	2.53E-08 +/-	2.30E-09	< 5.45E-08 +/-	2.73E-08	3.95E-08 +/-	7.79E-09	1.33E-06 +/-	2.30E-08
7 *	1.49E-07 +/-	6.82E-08	NA +/-	NA	< 4.94E-08 +/-	2.47E-08	< 3.82E-08 +/-	1.34E-08	7.87E-07 +/-	1.84E-08
8 *	< 8.40E-08 +/-	4.20E-08	1.11E-08 +/-	1.36E-09	< 5.11E-08 +/-	2.30E-08	4.76E-08 +/-	7.55E-09	1.63E-06 +/-	2.52E-08
9 *	< 1.17E-07 +/-	3.81E-08	NA +/-	NA	< 8.20E-08 +/-	2.89E-08	4.25E-08 +/-	7.77E-09	1.33E-06 +/-	3.16E-08
10 *	< 1.60E-07 +/-	5.13E-08	3.70E-08 +/-	3.09E-09	< 7.33E-08 +/-	2.89E-08	< 3.63E-08 +/-	1.81E-08	6.33E-07 +/-	2.56E-08
11 *	< 7.53E-08 +/-	3.77E-08	NA +/-	NA	< 4.02E-08 +/-	2.01E-08	< 1.73E-08 +/-	8.04E-09	2.81E-07 +/-	1.41E-08
12 *	< 1.61E-07 +/-	5.04E-08	NA +/-	NA	< 5.54E-08 +/-	2.01E-08	< 2.06E-08 +/-	5.86E-09	1.34E-07 +/-	9.15E-09
13 *	< 8.83E-08 +/-	4.42E-08	NA +/-	NA	< 7.09E-08 +/-	3.54E-08	< 1.71E-08 +/-	8.56E-09	8.08E-08 +/-	9.45E-09
14 *	< 9.20E-08 +/-	4.60E-08	NA +/-	NA	< 7.05E-08 +/-	2.90E-08	< 1.79E-08 +/-	8.60E-09	4.65E-08 +/-	7.09E-09
15 *	< 8.90E-08 +/-	4.45E-08	NA +/-	NA	< 4.76E-08 +/-	2.13E-08	< 1.53E-08 +/-	7.54E-09	4.72E-08 +/-	6.94E-09
16 *	< 6.56E-07 +/-	2.07E-07	NA +/-	NA	< 5.41E-08 +/-	2.71E-08	9.92E-08 +/-	9.97E-09	1.44E-07 +/-	1.28E-08

Table J-1. Concentrations of radionuclides and stable metals in Brunswick-1 cation resin waste-form leachates:
deionized water (uCi/ml decay corrected to 12/18/87 or ug/ml). (continued)

Sample	Pu-241		Cr		Fe		Co		Ni	
=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
1 *	NA +/-	NA	< 1.00E-02 +/-		2.10E-02 +/-	6.93E-03	< 5.00E-02 +/-		< 4.00E-02 +/-	
2 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
3 *	< 1.40E-08 +/-		6.00E-03 +/-	1.98E-03	3.20E-02 +/-	1.06E-02	< 5.00E-02 +/-		< 4.00E-02 +/-	
4 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
5 *	NA +/-	NA	1.80E-02 +/-	1.80E-03	1.92E-01 +/-	1.92E-02	< 5.00E-02 +/-		< 4.00E-02 +/-	
6 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
7 *	NA +/-	NA	< 1.00E-02 +/-		6.80E-02 +/-	2.24E-02	< 5.00E-02 +/-		< 4.00E-02 +/-	
8 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
9 *	NA +/-	NA	< 1.00E-02 +/-		2.80E-02 +/-	9.24E-03	< 5.00E-02 +/-		< 4.00E-02 +/-	
10 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
11 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
12 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA

Table J-2. Concentrations of radionuclides and stable metals in Brunswick-1 cation resin waste-form leachates: synthetic Barnwell ground water with pH 10.4 (uCi/ml decay corrected to 12/18/87 or ug/ml).

Sample	Mn-54	Fe-55	Co-58	Co-60	Ni-63
PR *	< 4.42E-08 +/- 1.20E-08	NA +/- NA	< 1.45E-07 +/- 7.27E-08	1.07E-07 +/- 1.62E-08	NA +/- NA
1 *	< 5.21E-08 +/- 1.33E-08	NA +/- NA	< 8.37E-07 +/- 3.54E-07	7.83E-08 +/- 7.58E-09	NA +/- NA
2 *	< 6.42E-08 +/- 1.63E-08	6.75E-07 +/- 7.93E-08	< 1.35E-06 +/- 4.82E-07	6.69E-08 +/- 1.01E-08	3.99E-06 +/- 3.10E-07
3 *	< 1.09E-07 +/- 1.44E-08	NA +/- NA	< 7.22E-07 +/- 3.61E-07	4.58E-07 +/- 1.60E-08	NA +/- NA
4 *	< 4.30E-08 +/- 1.21E-08	1.36E-07 +/- 2.03E-08	< 6.92E-07 +/- 3.46E-07	2.14E-07 +/- 9.64E-09	1.09E-06 +/- 1.67E-07
5 *	< 1.51E-07 +/- 2.09E-08	NA +/- NA	< 1.10E-06 +/- 4.69E-07	6.36E-07 +/- 1.73E-08	NA +/- NA
6 *	< 5.29E-08 +/- 2.07E-08	1.60E-07 +/- 2.03E-08	< 2.45E-06 +/- 8.52E-07	7.76E-08 +/- 1.07E-08	7.54E-07 +/- 1.16E-07
7 *	< 3.27E-08 +/- 1.64E-08	NA +/- NA	< 9.44E-07 +/- 3.45E-07	1.01E-07 +/- 7.47E-09	NA +/- NA
8 *	< 3.18E-08 +/- 1.59E-08	3.12E-06 +/- 1.90E-07	< 8.31E-07 +/- 4.15E-07	2.66E-07 +/- 1.19E-08	2.66E-06 +/- 3.10E-07
9 *	< 5.12E-08 +/- 1.32E-08	NA +/- NA	< 8.02E-07 +/- 3.94E-07	1.84E-07 +/- 9.49E-09	NA +/- NA
10 *	< 3.40E-08 +/- 1.70E-08	1.62E-06 +/- 2.80E-08	< 8.21E-07 +/- 4.11E-07	5.95E-07 +/- 1.57E-08	7.28E-07 +/- 1.13E-07
11 *	< 8.32E-08 +/- 2.42E-08	NA +/- NA	< 3.30E-06 +/- 1.65E-06	2.85E-07 +/- 1.21E-08	NA +/- NA
12 *	< 6.72E-08 +/- 2.08E-08	NA +/- NA	< 2.11E-06 +/- 8.54E-07	1.53E-07 +/- 9.35E-09	NA +/- NA

Sample	Zn-65	Sr-90	Sb-125	Cs-134	Cs-137
PR *	< 5.44E-08 +/- 2.72E-08	NA +/- NA	< 4.79E-08 +/- 2.39E-08	< 2.41E-08 +/- 1.21E-08	< 4.05E-08 +/- 7.06E-09
1 *	< 5.88E-08 +/- 2.94E-08	1.33E-08 +/- 1.92E-09	< 8.41E-08 +/- 2.39E-08	5.11E-08 +/- 7.12E-09	7.83E-07 +/- 2.19E-08
2 *	< 9.08E-08 +/- 4.54E-08	1.40E-08 +/- 1.69E-09	< 6.11E-08 +/- 2.45E-08	1.08E-07 +/- 8.46E-09	1.00E-06 +/- 2.22E-06
3 *	< 7.23E-08 +/- 3.29E-08	NA +/- NA	< 8.23E-08 +/- 2.44E-08	9.01E-08 +/- 7.96E-09	2.55E-06 +/- 4.81E-08
4 *	< 5.99E-08 +/- 3.00E-08	9.78E-09 +/- 2.20E-09	< 4.87E-08 +/- 2.44E-08	9.93E-08 +/- 8.35E-09	3.27E-06 +/- 5.23E-08
5 *	< 1.27E-07 +/- 3.93E-08	NA +/- NA	< 9.21E-08 +/- 2.61E-06	4.82E-08 +/- 7.06E-09	1.38E-06 +/- 3.35E-08
6 *	< 1.66E-07 +/- 4.80E-08	9.91E-09 +/- 1.35E-09	< 8.25E-08 +/- 3.37E-08	6.49E-08 +/- 8.36E-09	1.06E-06 +/- 4.44E-08
7 *	< 6.51E-08 +/- 3.25E-08	NA +/- NA	< 5.19E-08 +/- 2.00E-08	3.12E-08 +/- 5.86E-09	8.24E-07 +/- 2.00E-08
8 *	< 6.34E-08 +/- 3.17E-08	1.44E-06 +/- 1.02E-07	< 4.19E-08 +/- 2.10E-08	5.02E-08 +/- 6.67E-09	1.55E-06 +/- 4.09E-08
9 *	< 7.40E-08 +/- 3.32E-08	NA +/- NA	< 8.11E-08 +/- 2.11E-08	< 2.72E-08 +/- 1.19E-08	1.15E-06 +/- 2.47E-08
10 *	< 1.38E-07 +/- 4.23E-08	1.38E-06 +/- 9.56E-08	< 3.61E-08 +/- 1.81E-08	< 2.82E-08 +/- 8.72E-09	5.58E-07 +/- 2.38E-08
11 *	< 1.03E-07 +/- 4.82E-08	NA +/- NA	< 5.56E-08 +/- 2.78E-08	< 3.87E-08 +/- 1.94E-08	3.00E-07 +/- 1.86E-08
12 *	< 8.06E-08 +/- 4.00E-08	NA +/- NA	< 6.01E-08 +/- 1.89E-08	< 2.33E-08 +/- 8.30E-09	1.33E-07 +/- 8.93E-09

Table J-2. Concentrations of radionuclides and stable metals in Brunswick-1 cation resin waste-form leachates:
synthetic Barnwell ground water with pH 10.4 (uCi/ml decay corrected to 12/18/87 or ug/ml). (continued)

Sample	Pu-241		Cr		Fe		Co		Ni	
*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
1 #	NA +/-	NA	< 5.00E-02 +/-		1.45E-01 +/-	4.78E-02	< 2.50E-01 +/-		< 2.00E-01 +/-	
2 #	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
3 #	< 1.40E-08 +/-		< 5.00E-02 +/-		< 3.75E-01 +/-		< 2.50E-01 +/-		< 2.00E-01 +/-	
4 #	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
5 #	NA +/-	NA	< 1.00E-02 +/-		< 3.75E-01 +/-		< 2.50E-01 +/-		< 2.00E-01 +/-	
6 #	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
7 #	NA +/-	NA	< 5.00E-02 +/-		8.20E-02 +/-	2.71E-02	< 2.50E-01 +/-		< 2.00E-01 +/-	
8 #	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
9 #	NA +/-	NA	< 5.00E-02 +/-		8.90E-02 +/-	2.94E-02	< 2.50E-01 +/-		< 2.00E-01 +/-	
10 #	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
11 #	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
12 #	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA

Table J-3. Concentrations of radionuclides and stable metals in Brunswick-1 cation resin waste-form leachates: synthetic Barnwell ground water with pH 4.2 (uCi/ml decay corrected to 12/18/87 or ug/ml).

Sample	Mn-54		Fe-55		Co-58		Co-60		Ni-63	
PR *	< 3.82E-08	+/- 1.25E-08	NA +/-	NA	< 2.26E-07	+/- 8.19E-08	< 2.14E-08	+/- 1.07E-08	NA +/-	NA
1 *	< 3.61E-08	+/- 1.40E-08	NA +/-	NA	< 1.45E-06	+/- 3.81E-07	7.33E-08	+/- 8.67E-09	NA +/-	NA
2 *	2.44E-08	+/- 1.18E-08	7.07E-08	+/- 1.00E-08	< 7.90E-07	+/- 3.95E-07	7.75E-08	+/- 8.55E-09	1.28E-06	+/- 1.97E-07
3 *	< 2.27E-08	+/- 1.13E-08	NA +/-	NA	< 1.15E-06	+/- 3.62E-07	1.57E-07	+/- 8.73E-09	NA +/-	NA
4 *	< 2.95E-08	+/- 1.47E-08	7.23E-07	+/- 8.57E-08	< 1.28E-06	+/- 4.92E-07	1.96E-07	+/- 1.15E-08	2.88E-06	+/- 4.42E-07
5 *	< 3.11E-08	+/- 1.56E-08	NA +/-	NA	< 7.71E-07	+/- 3.66E-07	2.19E-07	+/- 1.10E-08	NA +/-	NA
6 *	< 5.10E-08	+/- 1.82E-08	1.87E-07	+/- 2.29E-08	< 1.69E-06	+/- 5.59E-07	1.21E-07	+/- 1.12E-08	2.12E-06	+/- 3.25E-07
7 *	< 3.33E-08	+/- 1.66E-08	NA +/-	NA	< 1.28E-06	+/- 5.37E-07	1.32E-07	+/- 1.18E-08	NA +/-	NA
8 *	< 3.17E-08	+/- 1.29E-08	1.26E-06	+/- 2.10E-08	< 1.15E-06	+/- 3.77E-07	1.98E-07	+/- 1.11E-08	1.98E-06	+/- 3.02E-07
9 *	< 7.05E-08	+/- 2.23E-08	NA +/-	NA	< 1.47E-06	+/- 7.29E-07	2.89E-07	+/- 1.29E-08	NA +/-	NA
10 *	< 3.08E-08	+/- 1.54E-08	3.51E-07	+/- 4.25E-08	< 9.27E-07	+/- 4.05E-07	2.04E-07	+/- 9.73E-09	1.39E-06	+/- 2.14E-07
11 *	< 3.55E-08	+/- 1.78E-08	NA +/-	NA	< 1.96E-06	+/- 8.12E-07	1.90E-07	+/- 1.01E-08	NA +/-	NA
12 *	< 5.27E-08	+/- 1.58E-08	NA +/-	NA	< 1.66E-06	+/- 8.29E-07	1.05E-07	+/- 8.92E-09	NA +/-	NA

Sample	Zn-65		Sr-90		Sb-125		Cs-134		Cs-137	
PR *	< 4.40E-08	+/- 2.20E-08	NA +/-	NA	< 4.48E-08	+/- 2.24E-08	< 2.02E-08	+/- 1.01E-08	< 1.62E-08	+/- 8.10E-09
1 *	< 5.54E-08	+/- 2.77E-08	7.93E-09	+/- 1.98E-09	< 5.26E-08	+/- 2.01E-08	3.07E-08	+/- 5.30E-09	8.44E-07	+/- 3.17E-08
2 *	< 5.57E-08	+/- 2.79E-08	1.04E-08	+/- 1.55E-09	< 4.18E-08	+/- 2.09E-08	8.75E-08	+/- 6.45E-09	1.13E-06	+/- 2.22E-08
3 *	< 8.66E-08	+/- 4.33E-08	NA +/-	NA	< 5.21E-08	+/- 2.61E-08	1.12E-07	+/- 7.56E-09	2.25E-06	+/- 2.92E-08
4 *	< 9.38E-08	+/- 3.94E-08	7.98E-09	+/- 1.21E-09	< 7.18E-08	+/- 2.30E-08	1.11E-07	+/- 8.22E-09	2.67E-06	+/- 3.95E-08
5 *	< 1.05E-07	+/- 3.33E-08	NA +/-	NA	< 4.29E-08	+/- 2.15E-08	5.82E-08	+/- 6.93E-09	1.93E-06	+/- 4.07E-08
6 *	< 1.46E-07	+/- 5.23E-08	1.60E-08	+/- 1.72E-09	< 9.33E-08	+/- 2.79E-08	5.93E-08	+/- 1.08E-08	1.44E-06	+/- 5.27E-08
7 *	< 1.63E-07	+/- 6.49E-08	NA +/-	NA	< 4.90E-08	+/- 2.45E-08	5.10E-08	+/- 7.67E-09	8.78E-07	+/- 3.74E-08
8 *	< 6.55E-08	+/- 3.27E-08	1.49E-08	+/- 1.82E-09	< 4.16E-08	+/- 2.08E-08	4.55E-08	+/- 6.14E-09	1.21E-06	+/- 2.55E-08
9 *	< 1.93E-07	+/- 9.65E-08	NA +/-	NA	< 9.27E-08	+/- 3.21E-08	< 3.60E-08	+/- 1.80E-08	7.82E-07	+/- 3.20E-08
10 *	< 6.39E-08	+/- 3.19E-08	2.87E-09	+/- 1.32E-09	< 3.72E-08	+/- 1.86E-08	< 2.37E-08	+/- 1.01E-08	2.84E-07	+/- 9.73E-09
11 *	< 1.41E-07	+/- 5.37E-08	NA +/-	NA	< 4.96E-08	+/- 2.03E-08	< 3.05E-08	+/- 8.39E-09	1.87E-07	+/- 9.97E-09
12 *	< 7.64E-08	+/- 3.82E-08	NA +/-	NA	< 4.95E-08	+/- 2.31E-08	< 1.80E-08	+/- 9.00E-09	9.68E-08	+/- 9.92E-09

Table J-3. Concentrations of radionuclides and stable metals in Brunswick-1 cation resin waste-form leachates:
synthetic Barnwell ground water with pH 4.2 (uCi/ml decay corrected to 12/18/87 or ug/ml). (continued)

Sample	Pu-241		Cr		Fe		Co		Ni	
*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
1 *	NA +/-	NA	< 5.00E-02 +/-		< 3.75E-01 +/-		< 2.50E-01 +/-		< 2.00E-01 +/-	
2 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
3 *	7.02E-09 +/-	7.02E-09	< 5.00E-02 +/-		< 3.75E-01 +/-		< 2.50E-01 +/-		< 2.00E-01 +/-	
4 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
5 *	NA +/-	NA	< 5.00E-02 +/-		8.90E-02 +/-	2.94E-02	< 2.50E-01 +/-		< 2.00E-01 +/-	
6 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
7 *	NA +/-	NA	< 5.00E-02 +/-		8.60E-02 +/-	2.84E-02	< 2.50E-01 +/-		< 2.00E-01 +/-	
8 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
9 *	NA +/-	NA	< 5.00E-02 +/-		8.00E-02 +/-	2.64E-02	< 2.50E-01 +/-		< 2.00E-01 +/-	
10 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
11 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
12 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA

Table J-4. Concentrations of radionuclides and stable metals in Brunswick-1 cation resin waste-form leachates: synthetic Hanford ground water with pH 8.9 (uCi/ml decay corrected to 12/18/87 or ug/ml).

Sample	Mn-54		Fe-55		Co-58		Co-60		Ni-63	
PR *	3.87E-08 +/-	1.51E-08	NA +/-	NA	< 1.77E-07 +/-	8.85E-08	2.26E-07 +/-	1.65E-08	NA +/-	NA
1 *	< 4.44E-08 +/-	1.40E-08	NA +/-	NA	< 1.39E-06 +/-	3.80E-07	4.08E-08 +/-	7.42E-09	3.38E-06 +/-	3.10E-07
2 *	< 4.38E-08 +/-	1.26E-08	8.66E-08 +/-	1.02E-08	< 7.31E-07 +/-	3.07E-07	9.61E-08 +/-	8.63E-09	NA +/-	NA
3 *	< 3.00E-08 +/-	1.50E-08	NA +/-	NA	< 7.72E-07 +/-	3.86E-07	1.83E-07 +/-	1.12E-08	NA +/-	NA
4 *	< 2.92E-08 +/-	1.46E-08	1.53E-06 +/-	1.79E-07	< 9.99E-07 +/-	5.00E-07	1.76E-07 +/-	8.98E-09	2.94E-07 +/-	5.10E-08
5 *	< 4.99E-08 +/-	1.44E-08	NA +/-	NA	< 8.12E-07 +/-	3.73E-07	1.86E-07 +/-	9.05E-09	NA +/-	NA
6 *	< 5.47E-08 +/-	1.83E-08	1.47E-07 +/-	1.86E-08	< 1.15E-06 +/-	5.46E-07	1.42E-07 +/-	1.30E-08	9.11E-06 +/-	6.10E-07
7 *	1.74E-07 +/-	1.93E-08	NA +/-	NA	< 9.35E-07 +/-	4.67E-07	7.53E-07 +/-	1.62E-08	NA +/-	NA
8 *	< 3.62E-08 +/-	1.81E-08	8.27E-08 +/-	1.18E-08	< 1.35E-06 +/-	4.44E-07	3.83E-07 +/-	1.37E-08	1.24E-07 +/-	9.00E-09
9 *	< 3.21E-08 +/-	1.60E-08	NA +/-	NA	< 7.23E-07 +/-	3.61E-07	2.46E-07 +/-	1.03E-08	NA +/-	NA
10 *	< 2.86E-08 +/-	1.43E-08	1.11E-06 +/-	1.30E-07	< 7.97E-07 +/-	3.98E-07	2.48E-07 +/-	1.03E-08	5.99E-07 +/-	6.10E-08
11 *	4.91E-08 +/-	2.16E-08	NA +/-	NA	< 1.62E-06 +/-	8.11E-07	2.54E-07 +/-	1.29E-08	NA +/-	NA
12 *	< 4.12E-08 +/-	2.06E-08	NA +/-	NA	< 1.88E-06 +/-	8.23E-07	1.54E-07 +/-	9.07E-09	NA +/-	NA

Sample	Zn-65		Sr-90		Sb-125		Cs-134		Cs-137	
PR *	< 5.26E-08 +/-	2.63E-08	NA +/-	NA	< 9.09E-08 +/-	3.40E-08	< 1.93E-08 +/-	9.67E-09	< 2.31E-08 +/-	6.57E-09
1 *	< 6.08E-08 +/-	3.04E-08	6.33E-09 +/-	1.57E-09	< 6.33E-08 +/-	2.01E-08	4.85E-08 +/-	5.83E-09	9.99E-07 +/-	1.99E-08
2 *	< 5.73E-08 +/-	2.87E-08	< 2.10E-09 +/-	NA	< 4.16E-08 +/-	2.08E-08	< 5.59E-08 +/-	9.89E-09	2.01E-06 +/-	2.80E-08
3 *	< 7.31E-08 +/-	3.44E-08	NA +/-	NA	< 4.85E-08 +/-	2.42E-08	1.02E-07 +/-	7.38E-09	3.12E-06 +/-	3.72E-08
4 *	< 8.62E-08 +/-	4.11E-08	6.38E-09 +/-	1.75E-09	< 5.71E-08 +/-	2.30E-08	8.34E-08 +/-	6.56E-09	2.52E-06 +/-	3.58E-08
5 *	< 6.39E-08 +/-	3.20E-08	NA +/-	NA	< 8.34E-08 +/-	2.24E-08	7.36E-08 +/-	7.87E-09	1.87E-06 +/-	4.11E-08
6 *	< 1.87E-07 +/-	6.20E-08	3.31E-08 +/-	2.81E-09	< 5.34E-08 +/-	2.67E-08	4.84E-08 +/-	1.05E-08	1.16E-06 +/-	4.03E-08
7 *	< 7.37E-08 +/-	3.68E-08	NA +/-	NA	< 5.98E-08 +/-	2.31E-08	< 2.03E-08 +/-	1.02E-08	6.98E-07 +/-	1.70E-08
8 *	< 1.53E-07 +/-	3.84E-08	7.67E-09 +/-	1.27E-09	< 3.74E-08 +/-	1.87E-08	2.33E-08 +/-	5.45E-09	6.03E-07 +/-	1.60E-08
9 *	< 9.32E-08 +/-	8.36E-09	NA +/-	NA	< 5.50E-08 +/-	2.10E-08	2.26E-08 +/-	5.37E-09	4.44E-07 +/-	1.94E-08
10 *	< 6.16E-08 +/-	3.08E-08	3.92E-08 +/-	1.32E-09	< 4.40E-08 +/-	2.20E-08	< 1.84E-08 +/-	8.45E-09	2.46E-07 +/-	1.24E-08
11 *	< 7.79E-08 +/-	3.90E-08	NA +/-	NA	< 4.35E-08 +/-	1.92E-08	< 3.15E-08 +/-	8.55E-09	1.29E-07 +/-	8.81E-09
12 *	< 1.34E-07 +/-	4.47E-08	NA +/-	NA	< 6.77E-08 +/-	3.38E-08	< 1.84E-08 +/-	7.76E-09	8.12E-08 +/-	7.62E-09

Table J-4. Concentrations of radionuclides and stable metals in Brunswick-1 cation resin waste-form leachates:
synthetic Hanford ground water with pH 8.9 (uCi/ml decay corrected to 12/18/87 or ug/ml). (continued)

Sample	Pu-241		Cr		Fe		Co		Ni	
*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
1 *	NA +/-	NA	< 5.00E-02 +/-		< 3.75E-01 +/-		< 2.50E-01 +/-		< 2.00E-01 +/-	
2 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
3 *	1.17E-08 +/-	7.02E-09	< 5.00E-02 +/-		< 3.75E-01 +/-		< 2.50E-01 +/-		< 2.00E-01 +/-	
4 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
5 *	NA +/-	NA	< 5.00E-02 +/-		< 3.75E-01 +/-		< 2.50E-01 +/-		< 2.00E-01 +/-	
6 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
7 *	NA +/-	NA	< 5.00E-02 +/-		< 3.75E-01 +/-		< 2.50E-01 +/-		< 2.00E-01 +/-	
8 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
9 *	NA +/-	NA	< 5.00E-02 +/-		< 3.75E-01 +/-		< 2.50E-01 +/-		< 2.00E-01 +/-	
10 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
11 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
12 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA

Table J-5. Concentrations of radionuclides and stable metals in Brunswick-1 cation resin waste-form leachates: synthetic seawater with pH 6.4 (uCi/ml decay corrected to 12/18/87 or ug/ml).

Sample	Mn-54		Fe-55		Co-58		Co-60		Ni-63	
*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
PR *	6.02E-08 +/-	1.92E-08	NA +/-	NA	< 2.26E-07 +/-	8.53E-08	1.16E-07 +/-	1.14E-08	NA +/-	NA
1 *	< 3.29E-08 +/-	1.22E-08	NA +/-	NA	< 1.37E-06 +/-	4.81E-07	5.21E-08 +/-	7.82E-09	NA +/-	NA
2 *	< 3.91E-08 +/-	1.58E-08	NA +/-	NA	< 3.50E-06 +/-	4.66E-07	1.48E-06 +/-	2.23E-08	NA +/-	NA
3 *	< 2.44E-08 +/-	1.22E-08	NA +/-	NA	< 1.46E-06 +/-	3.66E-07	1.82E-07 +/-	1.09E-08	NA +/-	NA
4 *	< 3.02E-08 +/-	1.51E-08	NA +/-	NA	< 8.87E-07 +/-	3.71E-07	1.49E-07 +/-	9.23E-09	NA +/-	NA
5 *	< 3.19E-08 +/-	1.23E-08	NA +/-	NA	< 9.41E-07 +/-	4.48E-07	1.14E-07 +/-	7.73E-09	NA +/-	NA
6 *	< 7.88E-08 +/-	3.04E-08	NA +/-	NA	< 1.36E-06 +/-	6.78E-07	9.66E-08 +/-	1.14E-08	NA +/-	NA
7 *	< 5.92E-08 +/-	1.88E-08	NA +/-	NA	< 7.21E-07 +/-	3.61E-07	9.53E-08 +/-	8.11E-09	NA +/-	NA
8 *	< 5.36E-08 +/-	1.36E-08	NA +/-	NA	< 8.85E-08 +/-	4.42E-08	3.80E-07 +/-	1.21E-08	NA +/-	NA
9 *	< 4.26E-08 +/-	1.96E-08	NA +/-	NA	< 1.57E-06 +/-	7.48E-07	4.90E-07 +/-	1.94E-08	NA +/-	NA
10 *	< 3.94E-08 +/-	1.97E-08	NA +/-	NA	< 1.08E-06 +/-	5.40E-07	5.45E-07 +/-	1.42E-08	NA +/-	NA
11 *	< 5.56E-08 +/-	2.78E-08	NA +/-	NA	< 2.44E-06 +/-	8.59E-07	4.76E-07 +/-	1.58E-08	NA +/-	NA
12 *	< 5.68E-08 +/-	1.69E-08	NA +/-	NA	< 1.71E-06 +/-	8.53E-07	2.59E-07 +/-	1.19E-08	NA +/-	NA

Sample	Zn-65		Sr-90		Sb-125		Cs-134		Cs-137	
*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
PR *	< 9.73E-08 +/-	4.87E-08	NA +/-	NA	< 4.56E-08 +/-	2.28E-08	< 2.94E-08 +/-	1.19E-08	1.02E-07 +/-	1.30E-08
1 *	< 5.59E-08 +/-	2.80E-08	3.95E-08 +/-	3.33E-09	< 4.21E-08 +/-	1.92E-08	3.76E-08 +/-	5.91E-09	6.54E-07 +/-	1.63E-08
2 *	< 8.29E-08 +/-	4.14E-08	NA +/-	NA	< 4.71E-08 +/-	2.35E-08	1.32E-07 +/-	9.02E-09	2.29E-06 +/-	2.95E-08
3 *	< 7.73E-08 +/-	3.17E-08	NA +/-	NA	< 5.79E-08 +/-	2.89E-08	1.31E-07 +/-	8.29E-09	2.44E-06 +/-	3.03E-08
4 *	< 5.80E-08 +/-	2.15E-08	NA +/-	NA	< 5.96E-08 +/-	2.27E-08	7.85E-08 +/-	8.39E-09	2.14E-06 +/-	2.85E-08
5 *	< 5.80E-08 +/-	2.90E-08	NA +/-	NA	< 5.87E-08 +/-	2.78E-08	3.63E-08 +/-	6.29E-09	1.12E-06 +/-	2.10E-08
6 *	< 2.39E-07 +/-	6.50E-08	NA +/-	NA	< 6.05E-08 +/-	2.77E-08	4.54E-08 +/-	1.14E-08	7.38E-07 +/-	3.70E-08
7 *	< 7.55E-08 +/-	3.21E-08	NA +/-	NA	< 4.30E-08 +/-	1.94E-08	< 2.15E-08 +/-	1.07E-08	5.60E-07 +/-	1.53E-08
8 *	< 8.92E-08 +/-	4.46E-08	NA +/-	NA	5.47E-08 +/-	2.47E-08	9.00E-08 +/-	7.06E-09	2.72E-06 +/-	7.14E-08
9 *	< 8.85E-08 +/-	4.42E-08	NA +/-	NA	< 7.34E-08 +/-	3.67E-08	8.40E-08 +/-	9.31E-09	2.43E-06 +/-	7.28E-08
10 *	< 7.47E-08 +/-	3.74E-08	NA +/-	NA	< 6.74E-08 +/-	2.13E-08	3.29E-08 +/-	8.55E-09	1.10E-06 +/-	2.59E-08
11 *	< 8.71E-08 +/-	4.35E-08	NA +/-	NA	< 4.66E-08 +/-	2.01E-08	3.63E-08 +/-	6.21E-09	4.07E-07 +/-	1.66E-08
12 *	< 1.05E-07 +/-	4.25E-08	NA +/-	NA	4.37E-08 +/-	2.11E-08	< 1.87E-08 +/-	7.69E-09	1.06E-07 +/-	8.78E-09

Table J-5. Concentrations of radionuclides and stable metals in Brunswick-1 cation resin waste-form leachates:
synthetic seawater with pH 6.4 (uCi/ml decay corrected to 12/18/87 or ug/ml). (continued)

Sample	Pu-241		Cr		Fe		Co		Ni	
*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
1 *	NA +/-	NA	8.50E-02 +/-	2.81E-02	< 3.75E-01 +/-		< 2.50E-01 +/-		< 2.00E-01 +/-	
2 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
3 *	1.29E-08 +/-	7.02E-09	3.06E-01 +/-	3.06E-02	< 3.75E-01 +/-		< 2.50E-01 +/-		< 2.00E-01 +/-	
4 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
5 *	NA +/-	NA	1.16E-01 +/-	1.16E-02	< 3.75E-01 +/-		< 2.50E-01 +/-		< 2.00E-01 +/-	
6 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
7 *	NA +/-	NA	3.80E-02 +/-	1.25E-02	< 3.75E-01 +/-		< 2.50E-01 +/-		< 2.00E-01 +/-	
8 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
9 *	NA +/-	NA	5.49E-01 +/-	5.49E-02	< 3.75E-01 +/-		< 2.50E-01 +/-		< 2.00E-01 +/-	
10 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
11 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
12 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA

Table J-6. Concentrations of radionuclides and stable metals in Brunswick-1 mixed-bed resin waste-form leachates: deionized water (uCi/ml decay corrected to 12/18/87 or ug/ml).

Sample	Mn-54		Fe-55		Co-58		Co-60		Ni-63	
PR *	3.23E-07 +/-	2.96E-08	NA +/-	NA	< 2.06E-07 +/-	1.03E-07	1.86E-06 +/-	4.29E-08	NA +/-	NA
1 *	4.37E-07 +/-	2.60E-08	NA +/-	NA	< 1.48E-06 +/-	7.39E-07	1.97E-06 +/-	2.66E-08	NA +/-	NA
2 *	9.76E-07 +/-	3.81E-08	6.31E-06 +/-	7.43E-07	< 3.05E-06 +/-	1.13E-06	4.91E-06 +/-	7.61E-08	7.32E-07 +/-	1.13E-07
3 *	< 4.67E-08 +/-	1.39E-08	NA +/-	NA	< 2.27E-06 +/-	6.16E-07	3.10E-07 +/-	1.14E-08	NA +/-	NA
4 *	5.84E-07 +/-	3.18E-08	2.62E-05 +/-	3.09E-06	1.99E-06 +/-	9.73E-07	2.63E-06 +/-	5.18E-08	8.19E-07 +/-	1.26E-07
5 *	< 4.60E-08 +/-	2.30E-08	NA +/-	NA	< 1.87E-06 +/-	9.35E-07	2.10E-07 +/-	1.10E-08	NA +/-	NA
6 *	< 3.43E-08 +/-	1.55E-08	1.18E-05 +/-	1.41E-06	< 1.28E-06 +/-	6.42E-07	5.84E-08 +/-	8.00E-09	3.78E-07 +/-	5.86E-08
7 *	< 5.73E-08 +/-	1.58E-08	NA +/-	NA	< 1.14E-06 +/-	5.71E-07	7.39E-08 +/-	8.48E-09	NA +/-	NA
8 *	2.19E-07 +/-	3.14E-08	4.58E-06 +/-	5.37E-07	< 1.69E-06 +/-	8.45E-07	1.31E-06 +/-	3.17E-08	3.17E-06 +/-	3.10E-07
9 *	< 4.20E-08 +/-	2.10E-08	NA +/-	NA	< 1.89E-06 +/-	9.47E-07	1.95E-07 +/-	1.43E-08	NA +/-	NA
10 *	< 5.38E-08 +/-	2.41E-08	2.38E-06 +/-	2.79E-07	< 2.22E-06 +/-	1.11E-06	1.84E-07 +/-	1.68E-08	3.91E-08 +/-	6.38E-09
11 *	9.09E-08 +/-	3.25E-08	NA +/-	NA	< 2.16E-06 +/-	9.08E-07	6.90E-07 +/-	1.80E-08	NA +/-	NA
12 *	< 4.27E-08 +/-	2.14E-08	NA +/-	NA	< 2.43E-06 +/-	1.22E-06	1.64E-07 +/-	1.28E-08	NA +/-	NA
13 *	< 3.96E-08 +/-	1.98E-08	NA +/-	NA	< 1.88E-06 +/-	9.40E-07	3.22E-07 +/-	1.55E-08	NA +/-	NA
14 *	< 4.54E-08 +/-	2.27E-08	NA +/-	NA	< 2.08E-06 +/-	1.04E-06	3.45E-07 +/-	1.43E-08	NA +/-	NA
15 *	< 4.51E-08 +/-	2.26E-08	NA +/-	NA	< 3.30E-06 +/-	1.65E-06	4.27E-07 +/-	1.33E-08	NA +/-	NA
16 *	1.23E-07 +/-	3.72E-08	NA +/-	NA	ND	+/ -	8.82E-07 +/-	2.59E-08	NA +/-	NA

Sample	Zn-65		Sr-90		Sb-125		Cs-134		Cs-137	
PR *	< 1.42E-07 +/-	4.83E-08	NA +/-	NA	< 1.03E-07 +/-	3.60E-08	< 2.70E-08 +/-	1.35E-08	5.15E-08 +/-	1.11E-08
1 *	< 1.59E-07 +/-	5.54E-08	NA +/-	NA	2.45E-07 +/-	2.15E-08	9.38E-08 +/-	1.02E-08	1.05E-06 +/-	2.93E-08
2 *	< 2.18E-07 +/-	7.23E-08	5.33E-07 +/-	3.66E-08	2.70E-07 +/-	2.41E-08	9.40E-08 +/-	9.21E-09	1.04E-06 +/-	2.07E-08
3 *	< 7.81E-08 +/-	3.90E-08	NA +/-	NA	3.02E-07 +/-	2.35E-08	1.36E-07 +/-	1.17E-08	1.42E-06 +/-	2.34E-08
4 *	< 1.66E-07 +/-	5.97E-08	3.74E-06 +/-	2.57E-07	2.21E-07 +/-	2.29E-08	5.56E-08 +/-	9.81E-09	4.55E-07 +/-	1.58E-08
5 *	< 9.96E-08 +/-	4.03E-08	NA +/-	NA	1.52E-07 +/-	1.98E-08	3.36E-08 +/-	7.36E-09	3.72E-07 +/-	1.44E-08
6 *	< 8.17E-08 +/-	3.93E-08	2.11E-06 +/-	1.46E-07	2.08E-07 +/-	2.85E-08	< 1.96E-08 +/-	8.90E-09	1.94E-07 +/-	1.12E-08
7 *	< 8.58E-08 +/-	3.76E-08	NA +/-	NA	1.46E-07 +/-	2.77E-08	< 4.05E-08 +/-	1.24E-08	1.59E-07 +/-	1.03E-08
8 *	< 1.20E-07 +/-	6.02E-08	6.27E-08 +/-	4.82E-09	1.11E-07 +/-	2.47E-08	3.82E-08 +/-	7.01E-09	2.66E-07 +/-	1.29E-08
9 *	< 2.03E-07 +/-	1.01E-07	NA +/-	NA	7.64E-08 +/-	2.74E-08	< 3.64E-08 +/-	1.82E-08	2.48E-07 +/-	1.43E-08
10 *	< 1.01E-07 +/-	5.07E-08	4.15E-08 +/-	3.53E-09	1.93E-07 +/-	2.65E-08	< 2.71E-08 +/-	9.29E-09	1.33E-07 +/-	1.61E-08
11 *	< 1.85E-07 +/-	5.24E-08	NA +/-	NA	7.80E-08 +/-	2.08E-08	< 2.67E-08 +/-	9.65E-09	7.76E-08 +/-	8.11E-09
12 *	< 9.93E-08 +/-	4.97E-08	NA +/-	NA	< 1.08E-07 +/-	2.72E-08	< 2.38E-08 +/-	8.24E-09	< 4.55E-08 +/-	2.28E-08
13 *	< 1.36E-07 +/-	4.90E-08	NA +/-	NA	1.47E-07 +/-	2.04E-08	< 2.09E-08 +/-	7.89E-09	2.10E-08 +/-	6.24E-09
14 *	1.15E-07 +/-	4.83E-08	NA +/-	NA	2.28E-07 +/-	3.06E-08	< 1.92E-08 +/-	9.60E-09	3.50E-08 +/-	8.36E-09
15 *	< 8.68E-08 +/-	3.84E-08	NA +/-	NA	3.42E-07 +/-	3.07E-08	< 3.75E-08 +/-	1.41E-08	6.67E-08 +/-	1.36E-08
16 *	< 2.14E-07 +/-	1.07E-07	NA +/-	NA	2.56E-07 +/-	2.31E-08	< 4.31E-08 +/-	1.38E-08	3.61E-08 +/-	1.30E-08

Table J-6. Concentrations of radionuclides and stable metals in Brunswick-1 mixed-bed resin waste-form leachates: deionized water (uCi/ml decay corrected to 12/18/87 or ug/ml). (continued)

Sample	Pu-241		Cr		Fe		Co		Ni	
*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
1 *	NA +/-	NA	1.40E-02 +/-	1.40E-03	< 7.50E-02 +/-		< 5.00E-02 +/-		< 4.00E-02 +/-	
2 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
3 *	1.29E-08 +/-	7.02E-09	< 1.00E-02 +/-		1.70E-02 +/-	5.61E-03	< 5.00E-02 +/-		< 4.00E-02 +/-	
4 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
5 *	NA +/-	NA	2.30E-02 +/-	2.30E-03	3.90E-02 +/-	1.29E-02	< 5.00E-02 +/-		< 4.00E-02 +/-	
6 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
7 *	NA +/-	NA	< 1.00E-02 +/-		< 7.50E-02 +/-		< 5.00E-02 +/-		< 4.00E-02 +/-	
8 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
9 *	NA +/-	NA	< 1.00E-02 +/-		3.60E-02 +/-	1.19E-02	< 5.00E-02 +/-		< 4.00E-02 +/-	
10 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
11 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
12 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA

Table J-7. Concentrations of radionuclides and stable metals in Brunswick-1 mixed-bed resin waste-form leachates: synthetic Barnwell ground water with pH 10.4 (uCi/ml decay corrected to 12/18/87 or ug/ml).

Sample	Mn-54		Fe-55		Co-58		Co-60		Ni-63	
PR *	2.21E-07 +/-	2.20E-08	NA +/-	NA	< 2.95E-07 +/-	1.03E-07	1.17E-06 +/-	3.27E-08	NA +/-	NA
1 *	< 2.97E-08 +/-	1.49E-08	NA +/-	NA	< 9.86E-07 +/-	3.70E-07	4.64E-07 +/-	1.23E-08	NA +/-	NA
2 *	3.55E-08 +/-	1.47E-08	3.678E-07 +/-	4.393E-08	< 1.32E-06 +/-	6.59E-07	2.20E-07 +/-	1.05E-08	4.959E-08 +/-	8.040E-09
3 *	< 5.46E-08 +/-	2.73E-08	NA +/-	NA	< 1.64E-06 +/-	8.22E-07	2.64E-07 +/-	1.53E-08	NA +/-	NA
4 *	< 3.42E-08 +/-	1.71E-08	9.774E-07 +/-	1.199E-07	< 1.44E-06 +/-	5.54E-07	9.07E-08 +/-	8.85E-09	4.979E-08 +/-	7.959E-09
5 *	< 5.40E-08 +/-	2.36E-08	NA +/-	NA	< 2.10E-06 +/-	1.05E-06	9.39E-08 +/-	1.40E-08	NA +/-	NA
6 *	< 6.25E-08 +/-	1.67E-08	6.983E-07 +/-	8.271E-08	< 1.57E-06 +/-	7.83E-07	6.77E-08 +/-	7.96E-09	4.929E-08 +/-	7.878E-09
7 *	< 4.65E-08 +/-	1.55E-08	NA +/-	NA	< 1.73E-06 +/-	6.67E-07	6.47E-08 +/-	8.73E-09	NA +/-	NA
8 *	< 3.93E-08 +/-	1.97E-08	4.021E-07 +/-	4.722E-08	< 1.48E-06 +/-	7.38E-07	1.57E-07 +/-	1.10E-08	3.838E-08 +/-	6.373E-09
9 *	< 3.15E-08 +/-	1.58E-08	NA +/-	NA	< 1.34E-06 +/-	6.68E-07	1.29E-07 +/-	9.76E-09	NA +/-	NA
10 *	< 3.79E-08 +/-	1.90E-08	2.504E-07 +/-	2.948E-08	< 1.79E-06 +/-	7.96E-07	1.20E-07 +/-	9.55E-09	6.383E-08 +/-	1.020E-08
11 *	< 3.66E-08 +/-	1.83E-08	NA +/-	NA	< 1.56E-06 +/-	7.80E-07	1.33E-07 +/-	1.08E-08	NA +/-	NA
12 *	< 5.62E-08 +/-	1.50E-08	NA +/-	NA	< 2.61E-06 +/-	9.24E-07	6.46E-08 +/-	7.55E-09	NA +/-	NA

Sample	Zn-65		Sr-90		Sb-125		Cs-134		Cs-137	
PR *	< 8.32E-08 +/-	3.66E-08	NA +/-	NA	< 8.08E-08 +/-	2.92E-08	< 2.10E-08 +/-	1.05E-08	< 1.79E-08 +/-	8.93E-09
1 *	< 9.90E-08 +/-	3.57E-08	1.46E-08 +/-	1.98E-09	3.83E-07 +/-	2.76E-08	9.05E-08 +/-	7.46E-09	1.10E-06 +/-	2.35E-08
2 *	< 6.39E-08 +/-	3.20E-08	2.81E-08 +/-	2.49E-09	1.90E-07 +/-	2.02E-08	3.61E-08 +/-	5.84E-09	4.83E-07 +/-	1.69E-08
3 *	< 1.17E-07 +/-	5.84E-08	NA +/-	NA	3.29E-07 +/-	3.26E-08	< 5.53E-08 +/-	9.19E-09	7.58E-07 +/-	1.87E-08
4 *	< 6.49E-08 +/-	3.24E-08	2.79E-08 +/-	2.48E-09	1.72E-07 +/-	2.40E-08	2.92E-08 +/-	5.83E-09	3.74E-07 +/-	1.28E-08
5 *	< 1.91E-07 +/-	8.19E-08	NA +/-	NA	1.84E-07 +/-	2.26E-08	< 2.78E-08 +/-	8.82E-09	1.56E-07 +/-	1.47E-08
6 *	< 8.19E-08 +/-	4.09E-08	4.72E-08 +/-	3.79E-09	9.10E-08 +/-	2.66E-08	< 1.23E-08 +/-	5.73E-09	8.89E-08 +/-	9.97E-09
7 *	< 1.50E-07 +/-	4.31E-08	NA +/-	NA	< 1.03E-07 +/-	3.06E-08	< 2.91E-08 +/-	8.65E-09	7.78E-08 +/-	1.15E-08
8 *	< 1.00E-07 +/-	3.91E-08	2.58E-08 +/-	2.35E-09	9.57E-08 +/-	2.63E-08	< 2.65E-08 +/-	1.09E-08	1.62E-07 +/-	1.22E-08
9 *	< 7.59E-08 +/-	3.79E-08	NA +/-	NA	1.02E-07 +/-	2.45E-08	< 3.25E-08 +/-	8.66E-09	1.16E-07 +/-	9.73E-09
10 *	< 7.54E-08 +/-	3.77E-08	1.88E-08 +/-	1.88E-09	5.53E-08 +/-	2.37E-08	< 2.23E-08 +/-	9.47E-09	8.95E-08 +/-	1.14E-08
11 *	< 7.70E-08 +/-	3.85E-08	NA +/-	NA	1.05E-07 +/-	2.03E-08	< 2.59E-08 +/-	9.48E-09	3.78E-08 +/-	6.51E-09
12 *	< 8.38E-08 +/-	4.19E-08	NA +/-	NA	1.80E-07 +/-	1.98E-08	< 2.44E-08 +/-	7.90E-09	2.02E-08 +/-	6.30E-09

Table J-7. Concentrations of radionuclides and stable metals in Brunswick-1 mixed-bed resin waste-form leachates:
synthetic Barnwell ground water with pH 10.4 (uCi/ml decay corrected to 12/18/87 or ug/ml). (continued)

Sample	Pu-241		Cr		Fe		Co		Ni	
=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
1 *	NA +/-	NA	< 5.00E-02 +/-		< 3.75E-01 +/-		< 2.50E-01 +/-		< 2.00E-01 +/-	
2 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
3 *	1.40E-08 +/-	7.02E-09	< 5.00E-02 +/-		8.00E-02 +/-	2.64E-02	< 2.50E-01 +/-		< 2.00E-01 +/-	
4 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
5 *	NA +/-	NA	< 5.00E-02 +/-		< 3.75E-01 +/-		< 2.50E-01 +/-		< 2.00E-01 +/-	
6 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
7 *	NA +/-	NA	< 5.00E-02 +/-		1.36E-01 +/-	4.49E-02	< 2.50E-01 +/-		< 2.00E-01 +/-	
8 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
9 *	NA +/-	NA	< 5.00E-02 +/-		< 3.75E-01 +/-		< 2.50E-01 +/-		< 2.00E-01 +/-	
10 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
11 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
12 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA

Table J-8. Concentrations of radionuclides and stable metals in Brunswick-1 mixed-bed resin waste-form leachates: synthetic Barnwell ground water with pH 4.2 (uCi/ml decay corrected to 12/18/87 or ug/ml).

Sample	Mn-54		Fe-55		Co-58		Co-60		Ni-63	
=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
PR *	2.98E-07 +/-	2.55E-08	NA +/-	NA	< 2.97E-07 +/-	1.20E-07	1.48E-06 +/-	5.42E-08	NA +/-	NA
1 *	< 5.91E-08 +/-	1.51E-08	NA +/-	NA	< 1.21E-06 +/-	6.04E-07	4.89E-07 +/-	1.34E-08	NA +/-	NA
2 *	3.70E-08 +/-	1.45E-08	3.41E-07 +/-	4.25E-08	< 2.01E-06 +/-	5.60E-07	1.64E-07 +/-	9.63E-09	1.48E-07 +/-	2.30E-08
3 *	4.97E-08 +/-	2.04E-08	NA +/-	NA	< 1.59E-06 +/-	7.97E-07	5.70E-07 +/-	1.66E-08	NA +/-	NA
4 *	< 3.66E-08 +/-	1.83E-08	5.21E-07 +/-	6.27E-08	< 1.14E-06 +/-	5.70E-07	2.19E-07 +/-	1.02E-08	8.63E-08 +/-	1.35E-08
5 *	< 3.69E-08 +/-	1.84E-08	NA +/-	NA	< 1.67E-06 +/-	7.10E-07	1.48E-07 +/-	1.08E-08	NA +/-	NA
6 *	< 5.09E-08 +/-	1.69E-08	4.49E-07 +/-	6.10E-08	< 1.14E-06 +/-	5.69E-07	5.77E-08 +/-	7.59E-09	4.48E-08 +/-	7.27E-09
7 *	< 3.59E-08 +/-	1.79E-08	NA +/-	NA	< 1.31E-06 +/-	6.55E-07	5.88E-08 +/-	7.72E-09	NA +/-	NA
8 *	< 3.81E-08 +/-	1.90E-08	2.07E-08 +/-	1.70E-09	< 1.44E-06 +/-	7.18E-07	2.26E-07 +/-	1.12E-08	6.70E-08 +/-	7.10E-09
9 *	< 5.31E-08 +/-	1.56E-08	NA +/-	NA	< 2.22E-06 +/-	6.85E-07	1.26E-07 +/-	9.73E-09	NA +/-	NA
10 *	< 3.72E-08 +/-	1.86E-08	3.63E-08 +/-	3.46E-09	< 1.41E-06 +/-	6.27E-07	1.59E-07 +/-	1.05E-08	3.45E-09 +/-	7.10E-10
11 *	< 3.55E-08 +/-	1.78E-08	NA +/-	NA	< 1.61E-06 +/-	8.06E-07	1.73E-07 +/-	9.35E-09	NA +/-	NA
12 *	< 6.01E-08 +/-	1.51E-08	NA +/-	NA	< 1.82E-06 +/-	8.08E-07	7.04E-08 +/-	1.11E-08	NA +/-	NA

Sample	Zn-65		Sr-90		Sb-125		Cs-134		Cs-137	
=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
PR *	< 7.54E-08 +/-	3.77E-08	NA +/-	NA	< 9.27E-08 +/-	2.85E-08	< 3.93E-08 +/-	1.22E-08	3.41E-08 +/-	1.68E-08
1 *	< 1.47E-07 +/-	4.19E-08	4.50E-09 +/-	2.35E-09	4.21E-07 +/-	2.26E-08	1.72E-07 +/-	8.72E-09	1.76E-06 +/-	2.57E-08
2 *	< 6.74E-08 +/-	3.37E-08	1.39E-08 +/-	1.64E-09	2.24E-07 +/-	2.73E-08	9.43E-08 +/-	7.79E-09	9.52E-07 +/-	1.91E-08
3 *	< 7.93E-08 +/-	3.96E-08	NA +/-	NA	3.68E-07 +/-	3.01E-08	1.37E-07 +/-	9.10E-09	1.50E-06 +/-	4.11E-08
4 *	< 7.42E-08 +/-	3.71E-08	1.47E-08 +/-	1.62E-09	2.47E-07 +/-	2.00E-08	8.38E-08 +/-	7.89E-09	8.73E-07 +/-	2.04E-08
5 *	< 9.85E-08 +/-	4.04E-08	NA +/-	NA	2.54E-07 +/-	2.93E-08	3.49E-08 +/-	6.79E-09	3.27E-07 +/-	1.36E-08
6 *	< 8.06E-08 +/-	4.03E-08	4.27E-09 +/-	1.14E-09	5.15E-08 +/-	2.29E-08	< 2.95E-08 +/-	8.71E-09	7.46E-08 +/-	1.07E-08
7 *	< 1.15E-07 +/-	4.17E-08	NA +/-	NA	7.87E-08 +/-	2.11E-08	< 2.94E-08 +/-	9.75E-09	8.59E-08 +/-	8.68E-09
8 *	< 8.18E-08 +/-	4.09E-08	< 2.10E-10 +/-		1.63E-07 +/-	2.81E-08	< 2.81E-08 +/-	9.05E-09	2.60E-07 +/-	1.90E-08
9 *	< 9.99E-05 +/-	4.99E-05	NA +/-	NA	9.87E-08 +/-	2.58E-08	< 2.81E-08 +/-	9.05E-09	1.73E-07 +/-	1.07E-08
10 *	< 7.85E-08 +/-	3.75E-08	2.10E-09 +/-	1.37E-09	1.55E-07 +/-	1.95E-08	< 2.73E-08 +/-	1.01E-08	1.19E-07 +/-	1.02E-08
11 *	< 7.94E-08 +/-	3.97E-08	NA +/-	NA	1.28E-07 +/-	2.20E-08	< 2.49E-08 +/-	6.80E-09	8.32E-08 +/-	7.67E-09
12 *	< 1.19E-07 +/-	5.94E-08	NA +/-	NA	1.19E-07 +/-	1.69E-08	< 1.85E-08 +/-	8.40E-09	2.93E-08 +/-	7.45E-09

Table J-8. Concentrations of radionuclides and stable metals in Brunswick-1 mixed-bed resin waste-form leachates:
synthetic Barnwell ground water with pH 4.2 (uCi/ml decay corrected to 12/18/87 or ug/ml). (continued)

Sample	Pu-241		Cr		Fe		Co		Ni	
*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
1 *	NA +/-	NA	< 5.00E-02 +/-		< 3.75E-01 +/-		< 2.50E-01 +/-		< 2.00E-01 +/-	
2 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
3 *	2.34E-08 +/-	7.02E-09	< 5.00E-02 +/-		< 3.75E-01 +/-		3.00E-02 +/-	9.90E-03	< 2.00E-01 +/-	
4 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
5 *	NA +/-	NA	< 5.00E-02 +/-		< 3.75E-01 +/-		< 2.50E-01 +/-		< 2.00E-01 +/-	
6 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
7 *	NA +/-	NA	< 5.00E-02 +/-		7.50E-02 +/-	2.48E-02	< 2.50E-01 +/-		< 2.00E-01 +/-	
8 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
9 *	NA +/-	NA	< 5.00E-02 +/-		< 3.75E-01 +/-		< 2.50E-01 +/-		< 2.00E-01 +/-	
10 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
11 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
12 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA

Table J-9. Concentrations of radionuclides and stable metals in Brunswick-1 mixed-bed resin waste-form leachates: synthetic Hanford ground water with pH 8.9 (uCi/ml decay corrected to 12/18/87 or ug/ml).

Sample	Mn-54		Fe-55		Co-58		Co-60		Ni-63	
PR #	7.94E-07 +/-	4.57E-08	NA +/-	NA	< 2.78E-07 +/-	1.39E-07	3.93E-06 +/-	9.59E-08	NA +/-	NA
1 *	4.17E-07 +/-	3.25E-08	NA +/-	NA	< 4.89E-07 +/-	2.12E-07	2.46E-06 +/-	6.14E-08	NA +/-	NA
2 *	< 4.86E-08 +/-	1.33E-08	9.16E-08 +/-	6.90E-09	< 1.65E-06 +/-	5.60E-07	1.06E-07 +/-	8.71E-09	3.35E-07 +/-	5.10E-08
3 *	< 6.14E-08 +/-	1.61E-08	NA +/-	NA	< 1.46E-06 +/-	7.32E-07	1.94E-07 +/-	9.86E-09	NA +/-	NA
4 *	3.51E-07 +/-	2.65E-08	5.19E-07 +/-	1.20E-08	< 1.49E-06 +/-	7.46E-07	1.90E-06 +/-	3.44E-08	7.11E-08 +/-	1.12E-08
5 *	< 6.35E-08 +/-	1.75E-08	NA +/-	NA	< 3.46E-06 +/-	8.83E-07	1.27E-07 +/-	9.25E-09	NA +/-	NA
6 *	< 3.93E-08 +/-	1.51E-08	1.71E-06 +/-	8.65E-08	< 1.39E-06 +/-	6.47E-07	5.71E-08 +/-	9.11E-09	9.72E-06 +/-	7.20E-07
7 *	< 7.46E-08 +/-	1.94E-08	NA +/-	NA	< 2.11E-06 +/-	6.40E-07	3.47E-08 +/-	7.07E-09	NA +/-	NA
8 *	< 4.97E-08 +/-	2.10E-08	9.51E-08 +/-	5.20E-09	2.29E-06 +/-	9.76E-07	1.17E-07 +/-	1.06E-08	7.11E-08 +/-	1.02E-08
9 *	< 4.23E-08 +/-	2.11E-08	NA +/-	NA	< 1.37E-06 +/-	6.86E-07	1.11E-07 +/-	1.06E-08	NA +/-	NA
10 *	< 6.16E-08 +/-	1.55E-08	1.54E-07 +/-	8.65E-09	< 1.43E-06 +/-	5.92E-07	1.63E-07 +/-	9.05E-09	3.05E-08 +/-	2.03E-09
11 *	< 5.06E-08 +/-	1.75E-08	NA +/-	NA	< 2.23E-06 +/-	1.07E-06	1.71E-07 +/-	1.11E-08	NA +/-	NA
12 *	< 9.91E-08 +/-	2.67E-08	NA +/-	NA	< 2.40E-06 +/-	1.20E-06	8.63E-08 +/-	1.04E-08	NA +/-	NA

Sample	Zn-65		Sr-90		Sb-125		Cs-134		Cs-137	
PR #	< 2.34E-07 +/-	7.03E-08	NA +/-	NA	< 5.75E-08 +/-	2.87E-08	< 3.79E-08 +/-	1.83E-08	< 2.22E-08 +/-	1.11E-08
1 *	< 2.26E-07 +/-	4.18E-08	6.94E-09 +/-	1.63E-09	3.65E-07 +/-	2.49E-08	< 4.58E-08 +/-	2.29E-08	8.94E-07 +/-	2.72E-08
2 *	< 6.59E-08 +/-	3.30E-08	< 4.20E-09 +/-	NA	1.60E-07 +/-	1.77E-08	3.10E-08 +/-	6.90E-09	4.11E-07 +/-	1.29E-08
3 *	< 6.61E-08 +/-	3.31E-08	NA +/-	NA	2.65E-07 +/-	2.88E-08	5.11E-08 +/-	8.28E-09	6.98E-07 +/-	1.65E-08
4 *	< 1.67E-07 +/-	5.56E-08	< 2.10E-09 +/-	NA	9.42E-08 +/-	2.35E-08	< 2.91E-08 +/-	1.02E-08	1.43E-07 +/-	1.33E-08
5 *	< 7.81E-08 +/-	3.91E-08	NA +/-	NA	1.00E-07 +/-	2.51E-08	< 2.43E-08 +/-	1.04E-08	1.10E-07 +/-	9.88E-09
6 *	< 7.65E-08 +/-	3.82E-08	< 4.20E-09 +/-	NA	7.83E-08 +/-	2.25E-08	< 2.14E-08 +/-	8.40E-09	6.48E-08 +/-	8.98E-09
7 *	< 7.52E-08 +/-	3.76E-08	NA +/-	NA	< 8.16E-08 +/-	3.94E-08	< 2.39E-08 +/-	8.80E-09	6.73E-08 +/-	9.33E-09
8 *	< 2.03E-07 +/-	5.76E-08	< 2.70E-09 +/-	NA	1.13E-07 +/-	2.60E-08	< 3.54E-08 +/-	1.03E-08	1.19E-07 +/-	1.45E-08
9 *	< 8.01E-08 +/-	4.00E-08	NA +/-	NA	< 1.38E-07 +/-	4.16E-08	< 3.40E-08 +/-	9.62E-09	1.04E-07 +/-	9.34E-09
10 *	< 9.10E-08 +/-	3.73E-08	< 2.10E-10 +/-	NA	1.39E-07 +/-	2.38E-08	< 1.47E-08 +/-	7.34E-09	8.99E-08 +/-	8.40E-09
11 *	< 7.58E-08 +/-	3.79E-08	NA +/-	NA	1.64E-07 +/-	2.20E-08	< 2.03E-08 +/-	9.97E-09	4.79E-08 +/-	1.26E-08
12 *	< 3.45E-07 +/-	6.43E-08	NA +/-	NA	2.26E-07 +/-	3.05E-08	< 2.21E-08 +/-	1.11E-08	< 3.84E-08 +/-	1.92E-08

Table J-9. Concentrations of radionuclides and stable metals in Brunswick-1 mixed-bed resin waste-form leachates: synthetic Hanford ground water with pH 8.9 (uCi/ml decay corrected to 12/18/87 or ug/ml). (continued)

Sample	Pu-241		Cr		Fe		Co		Ni	
=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
1 *	NA +/-	NA	< 5.00E-02 +/-		< 3.75E-01 +/-		< 2.50E-01 +/-		< 2.00E-01 +/-	
2 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
3 *	< 1.40E-08 +/-		< 5.00E-02 +/-		8.60E-02 +/-	2.84E-02	< 2.50E-01 +/-		< 2.00E-01 +/-	
4 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
5 *	NA +/-	NA	< 5.00E-02 +/-		8.00E-02 +/-	2.64E-02	< 2.50E-01 +/-		< 2.00E-01 +/-	
6 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
7 *	NA +/-	NA	< 5.00E-02 +/-		< 3.75E-01 +/-		< 2.50E-01 +/-		< 2.00E-01 +/-	
8 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
9 *	NA +/-	NA	< 5.00E-02 +/-		< 3.75E-01 +/-		< 2.50E-01 +/-		< 2.00E-01 +/-	
10 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
11 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
12 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA

Table J-10. Concentrations of radionuclides and stable metals in Brunswick-1 mixed-bed resin waste-form leachates: synthetic seawater with pH 6.4 (uCi/ml decay corrected to 12/18/87 or ug/ml).

Sample	Mn-54		Fe-55		Co-58		Co-60		Ni-63	
PR *	< 4.46E-08	+/- 2.23E-08	NA +/-	NA	< 3.58E-07	+/- 1.79E-07	< 4.04E-08	+/- 1.95E-08	NA +/-	NA
1 *	< 4.09E-08	+/- 1.37E-08	NA +/-	NA	< 1.02E-06	+/- 5.09E-07	7.16E-08	+/- 7.31E-09	NA +/-	NA
2 *	< 3.99E-08	+/- 1.30E-08	NA +/-	NA	< 1.45E-06	+/- 5.46E-07	1.35E-07	+/- 9.41E-09	NA +/-	NA
3 *	< 5.44E-08	+/- 2.04E-08	NA +/-	NA	< 2.73E-06	+/- 9.48E-07	1.56E-07	+/- 1.05E-08	NA +/-	NA
4 *	< 4.65E-08	+/- 2.32E-08	NA +/-	NA	< 2.06E-06	+/- 9.54E-07	6.18E-08	+/- 1.23E-08	NA +/-	NA
5 *	< 3.93E-08	+/- 1.53E-08	NA +/-	NA	< 1.73E-06	+/- 8.65E-07	6.55E-08	+/- 8.30E-09	NA +/-	NA
6 *	< 7.21E-08	+/- 2.06E-08	NA +/-	NA	< 2.19E-06	+/- 1.09E-06	4.62E-08	+/- 1.12E-08	NA +/-	NA
7 *	< 4.07E-08	+/- 1.55E-08	NA +/-	NA	< 1.70E-06	+/- 6.38E-07	1.45E-07	+/- 1.16E-08	NA +/-	NA
8 *	< 7.05E-08	+/- 2.19E-08	NA +/-	NA	< 2.38E-06	+/- 1.19E-06	5.29E-07	+/- 2.26E-08	NA +/-	NA
9 *	< 5.20E-08	+/- 1.81E-08	NA +/-	NA	< 1.77E-06	+/- 8.85E-07	4.49E-07	+/- 1.51E-08	NA +/-	NA
10 *	< 5.89E-08	+/- 2.03E-08	NA +/-	NA	< 2.54E-06	+/- 1.12E-06	2.77E-06	+/- 1.47E-07	NA +/-	NA
11 *	< 5.03E-08	+/- 1.92E-08	NA +/-	NA	< 1.62E-06	+/- 8.11E-07	2.76E-07	+/- 1.29E-08	NA +/-	NA
12 *	< 3.56E-08	+/- 1.78E-08	NA +/-	NA	< 1.67E-06	+/- 8.36E-07	9.15E-08	+/- 7.92E-09	NA +/-	NA

Sample	Zn-65		Sr-90		Sb-125		Cs-134		Cs-137	
PR *	< 1.13E-07	+/- 5.63E-08	NA +/-	NA	< 8.72E-08	+/- 4.36E-08	< 4.40E-08	+/- 1.45E-08	< 3.47E-08	+/- 1.73E-08
1 *	< 4.09E-08	+/- 2.05E-08	3.19E-08	+/- 2.86E-09	5.31E-08	+/- 2.59E-08	3.61E-08	+/- 7.22E-09	3.13E-07	+/- 1.15E-08
2 *	< 1.34E-07	+/- 5.17E-08	NA +/-	NA	7.56E-08	+/- 2.12E-08	4.27E-08	+/- 7.89E-09	4.61E-07	+/- 1.36E-08
3 *	< 9.68E-08	+/- 4.79E-08	NA +/-	NA	9.49E-08	+/- 3.81E-08	5.99E-08	+/- 1.05E-08	6.82E-07	+/- 3.39E-08
4 *	< 1.01E-07	+/- 5.03E-08	NA +/-	NA	< 7.95E-08	+/- 3.08E-08	6.25E-08	+/- 1.16E-08	5.37E-07	+/- 3.17E-08
5 *	< 1.03E-07	+/- 5.17E-08	NA +/-	NA	< 8.19E-08	+/- 2.36E-08	5.87E-08	+/- 7.61E-09	3.99E-07	+/- 1.47E-08
6 *	< 2.09E-07	+/- 6.47E-08	NA +/-	NA	< 9.33E-08	+/- 4.67E-08	< 3.49E-08	+/- 1.75E-08	3.87E-07	+/- 3.11E-08
7 *	< 9.14E-08	+/- 4.57E-08	NA +/-	NA	< 1.01E-07	+/- 5.03E-08	2.85E-08	+/- 7.68E-09	3.63E-07	+/- 1.42E-08
8 *	< 1.64E-07	+/- 8.18E-08	NA +/-	NA	1.63E-07	+/- 2.19E-08	1.30E-07	+/- 2.50E-08	2.14E-06	+/- 8.90E-08
9 *	< 9.19E-08	+/- 4.60E-08	NA +/-	NA	1.21E-07	+/- 2.52E-08	1.06E-07	+/- 9.65E-09	1.18E-06	+/- 2.40E-08
10 *	< 1.11E-07	+/- 5.54E-08	NA +/-	NA	1.44E-07	+/- 2.77E-08	8.04E-08	+/- 9.07E-09	6.06E-07	+/- 2.10E-08
11 *	< 9.08E-08	+/- 4.09E-08	NA +/-	NA	2.07E-07	+/- 2.81E-08	< 3.61E-08	+/- 9.13E-09	2.65E-07	+/- 1.13E-08
12 *	< 5.49E-08	+/- 2.74E-08	NA +/-	NA	1.96E-07	+/- 2.12E-08	< 1.93E-08	+/- 7.80E-09	1.15E-07	+/- 8.47E-09

Table J-10. Concentrations of radionuclides and stable metals in Brunswick-1 mixed-bed resin waste-form leachates: synthetic seawater with pH 6.4 (uCi/ml decay corrected to 12/18/87 or ug/ml). (continued)

Sample	Pu-241		Cr		Fe		Co		Ni	
=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
1 *	NA +/-	NA	1.48E-01 +/-	4.88E-02	< 3.75E-01 +/-		< 2.50E-01 +/-		< 2.00E-01 +/-	
2 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
3 *	< 1.40E-08 +/-		2.54E-01 +/-	2.54E-02	< 3.75E-01 +/-		< 2.50E-01 +/-		< 2.00E-01 +/-	
4 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
5 *	NA +/-	NA	1.46E-01 +/-	1.46E-02	7.80E-02 +/-	2.57E-02	< 2.50E-01 +/-		< 2.00E-01 +/-	
6 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
7 *	NA +/-	NA	2.03E-01 +/-	2.03E-02	< 3.75E-01 +/-		< 2.50E-01 +/-		< 2.00E-01 +/-	
8 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
9 *	NA +/-	NA	1.13E+00 +/-	1.13E-01	< 3.75E-01 +/-		< 2.50E-01 +/-		< 2.00E-01 +/-	
10 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
11 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
12 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA

Table J-11. Concentrations of radionuclides and stable metals in James A. FitzPatrick mixed-bed resin waste-form leachates:
deionized water (uCi/ml decay corrected to 09/19/88 or ug/ml).

Sample	Mn-54		Fe-55		Co-58		Co-60		Ni-63	
PR *	2.72E-07 +/-	2.83E-08	NA +/-	NA	< 2.76E-06 +/-	1.38E-06	1.48E-06 +/-	4.03E-08	NA +/-	NA
1 *	1.61E-06 +/-	4.10E-08	NA +/-	NA	7.91E-06 +/-	1.44E-07	4.22E-05 +/-	4.13E-07	8.04E-06 +/-	6.11E-07
2 *	9.96E-06 +/-	1.39E-07	4.58E-06 +/-	3.16E-07	4.08E-05 +/-	2.69E-07	2.21E-04 +/-	2.03E-06	4.68E-05 +/-	2.04E-06
3 *	2.41E-06 +/-	8.46E-08	NA +/-	NA	8.03E-05 +/-	3.85E-07	4.32E-04 +/-	4.63E-06	2.04E-04 +/-	1.12E-05
4 *	1.92E-06 +/-	8.58E-08	3.86E-06 +/-	5.80E-08	8.69E-05 +/-	8.69E-07	4.72E-04 +/-	6.37E-06	1.62E-04 +/-	8.14E-06
5 *	3.21E-06 +/-	8.73E-08	NA +/-	NA	7.48E-05 +/-	4.49E-07	4.09E-04 +/-	3.15E-06	1.61E-04 +/-	9.16E-06
6 *	4.22E-06 +/-	8.94E-08	3.16E-06 +/-	2.21E-07	6.72E-05 +/-	7.19E-07	3.62E-04 +/-	2.86E-06	9.37E-05 +/-	5.09E-06
7 *	7.88E-06 +/-	1.15E-07	NA +/-	NA	7.26E-05 +/-	9.59E-07	3.93E-04 +/-	3.93E-06	9.57E-05 +/-	5.09E-06
8 *	1.16E-05 +/-	3.34E-07	2.53E-06 +/-	1.74E-07	2.62E-04 +/-	2.02E-06	1.43E-03 +/-	8.59E-06	2.44E-04 +/-	1.32E-05
9 *	1.08E-05 +/-	2.01E-07	NA +/-	NA	2.94E-04 +/-	2.85E-06	1.60E-03 +/-	9.62E-06	1.48E-04 +/-	8.14E-06
10 *	2.71E-06 +/-	5.82E-08	3.63E-07 +/-	2.53E-08	2.87E-04 +/-	1.55E-06	1.56E-03 +/-	1.02E-05	7.94E-05 +/-	4.07E-06
11 *	< 5.08E-07 +/-	2.25E-07	NA +/-	NA	2.42E-04 +/-	2.75E-06	1.33E-03 +/-	1.04E-05	NA +/-	NA
12 *	< 5.64E-07 +/-	2.18E-07	NA +/-	NA	2.13E-04 +/-	1.98E-06	1.18E-03 +/-	9.06E-06	NA +/-	NA
13 *	< 2.14E-06 +/-	5.75E-07	NA +/-	NA	3.33E-04 +/-	4.65E-05	1.60E-03 +/-	1.13E-05	NA +/-	NA

Sample	Zn-65		Sr-90		Sb-125		Cs-134		Cs-137	
PR *	< 1.97E-07 +/-	6.51E-08	NA +/-	NA	< 6.77E-08 +/-	3.00E-08	1.24E-07 +/-	1.39E-08	2.00E-07 +/-	1.10E-08
1 *	2.95E-07 +/-	7.47E-08	NA +/-	NA	< 1.26E-07 +/-	6.28E-08	8.87E-06 +/-	5.32E-08	1.59E-05 +/-	9.54E-08
2 *	3.75E-06 +/-	3.54E-07	NA +/-	NA	< 3.03E-07 +/-	1.51E-07	4.83E-05 +/-	1.84E-07	8.70E-05 +/-	2.35E-07
3 *	1.21E-06 +/-	3.28E-07	NA +/-	NA	< 7.09E-07 +/-	2.58E-07	9.83E-05 +/-	5.60E-07	1.75E-04 +/-	1.09E-06
4 *	3.49E-06 +/-	6.11E-07	NA +/-	NA	5.31E-07 +/-	2.03E-07	8.80E-05 +/-	5.63E-07	1.63E-04 +/-	1.45E-06
5 *	1.54E-06 +/-	2.97E-07	NA +/-	NA	< 6.72E-07 +/-	2.55E-07	6.26E-05 +/-	4.13E-07	1.13E-04 +/-	9.19E-07
6 *	3.07E-06 +/-	6.42E-07	NA +/-	NA	< 6.00E-07 +/-	2.16E-07	4.40E-05 +/-	2.99E-07	7.98E-05 +/-	5.02E-07
7 *	3.86E-06 +/-	9.20E-07	NA +/-	NA	9.70E-07 +/-	1.49E-07	3.69E-05 +/-	3.02E-07	6.67E-05 +/-	4.73E-07
8 *	1.05E-05 +/-	2.35E-06	NA +/-	NA	7.49E-07 +/-	3.29E-07	8.87E-05 +/-	4.79E-07	1.60E-04 +/-	7.50E-07
9 *	1.31E-05 +/-	2.89E-06	NA +/-	NA	< 8.75E-07 +/-	1.88E-08	5.89E-05 +/-	3.95E-07	1.06E-04 +/-	4.89E-07
10 *	1.24E-05 +/-	3.21E-06	NA +/-	NA	< 1.07E-06 +/-	5.36E-07	2.79E-05 +/-	1.59E-07	4.98E-05 +/-	2.29E-07
11 *	1.17E-05 +/-	3.01E-06	NA +/-	NA	5.83E-07 +/-	2.74E-07	1.24E-05 +/-	1.18E-07	2.18E-05 +/-	1.43E-06
12 *	3.74E-06 +/-	1.04E-06	NA +/-	NA	< 7.16E-07 +/-	3.58E-07	5.83E-06 +/-	9.32E-08	1.08E-05 +/-	1.54E-07
13 *	6.58E-06 +/-	2.68E-06	NA +/-	NA	< 1.32E-06 +/-	6.52E-07	3.64E-06 +/-	1.39E-07	7.24E-06 +/-	1.69E-07

Table J-11. Concentrations of radionuclides and stable metals in James A. FitzPatrick mixed-bed resin waste-form leachates:
deionized water (uCi/ml decay corrected to 09/19/88 or ug/ml). (continued)

Sample	Pu-241		Cr		Co		Fe		Ni	
1 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
2 *	NA +/-	NA	< 1.00E-02 +/-	NA	< 5.00E-02 +/-	NA	< 6.13E-02 +/-	NA	2.30E-02 +/-	7.59E-03
3 *	4.06E-08 +/-	1.02E-08	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
4 *	NA +/-	NA	< 1.00E-02 +/-	NA	< 5.00E-02 +/-	NA	< 7.50E-02 +/-	NA	6.89E-02 +/-	2.27E-02
5 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
6 *	NA +/-	NA	< 1.00E-02 +/-	NA	< 5.00E-02 +/-	NA	< 7.50E-02 +/-	NA	3.97E-02 +/-	1.31E-02
7 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
8 *	NA +/-	NA	< 1.00E-02 +/-	NA	< 5.00E-02 +/-	NA	< 2.87E-02 +/-	NA	2.87E-02 +/-	9.47E-03
9 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
10 *	NA +/-	NA	< 1.00E-02 +/-	NA	< 5.00E-02 +/-	NA	< 7.50E-02 +/-	NA	9.97E-02 +/-	3.29E-02

Table J-12. Concentrations of radionuclides and stable metals in James A. FitzPatrick mixed-bed resin waste-form leachates: synthetic Barnwell ground water with pH 10.4 (uCi/ml decay corrected to 09/19/88 or ug/ml).

Sample	Mn-54		Fe-55		Co-58		Co-60		Ni-63	
PR *	4.31E-07	+/- 2.93E-08	NA	+/- NA	< 2.88E-06	+/- 1.44E-06	2.36E-06	+/- 3.62E-08	NA	+/- NA
1 *	1.65E-06	+/- 3.55E-08	NA	+/- NA	5.84E-06	+/- 9.87E-08	3.06E-05	+/- 3.24E-07	2.14E-06	+/- 1.63E-07
2 *	3.03E-06	+/- 6.24E-08	3.32E-06	+/- 2.37E-07	3.15E-05	+/- 3.22E-07	1.68E-04	+/- 1.56E-06	1.80E-04	+/- 9.30E-06
3 *	1.58E-06	+/- 7.74E-08	NA	+/- NA	7.33E-05	+/- 1.01E-06	3.91E-04	+/- 5.55E-06	1.38E-04	+/- 7.13E-06
4 *	2.40E-06	+/- 1.39E-07	5.06E-06	+/- 3.16E-07	5.62E-05	+/- 7.47E-07	3.04E-04	+/- 4.04E-06	8.90E-05	+/- 5.00E-06
5 *	1.88E-06	+/- 1.10E-07	NA	+/- NA	5.42E-05	+/- 5.37E-07	2.95E-04	+/- 2.42E-06	NA	+/- NA
6 *	3.22E-06	+/- 9.81E-08	2.53E-06	+/- 1.74E-07	5.55E-05	+/- 4.72E-07	3.00E-04	+/- 2.49E-06	1.07E-04	+/- 6.00E-06
7 *	1.65E-06	+/- 9.26E-08	NA	+/- NA	4.86E-05	+/- 4.18E-07	2.66E-04	+/- 2.26E-06	7.74E-05	+/- 4.07E-06
8 *	9.42E-06	+/- 1.96E-07	6.16E-06	+/- 4.74E-07	2.42E-04	+/- 1.65E-06	1.31E-03	+/- 8.14E-06	2.20E-04	+/- 1.30E-05
9 *	2.67E-05	+/- 3.05E-07	NA	+/- NA	2.80E-04	+/- 2.77E-06	1.52E-03	+/- 9.42E-06	NA	+/- NA
10 *	2.57E-06	+/- 5.06E-07	1.33E-07	+/- 9.48E-09	3.34E-04	+/- 3.01E-05	1.84E-03	+/- 2.23E-05	1.35E-04	+/- 8.00E-06

Sample	Zn-65		Sr-90		Sb-125		Cs-134		Cs-137	
PR *	< 2.76E-07	+/- 9.11E-08	NA	+/- NA	< 4.55E-08	+/- 2.27E-08	1.14E-07	+/- 1.22E-08	1.80E-07	+/- 1.08E-08
1 *	6.97E-07	+/- 9.65E-08	NA	+/- NA	< 1.17E-07	+/- 4.82E-08	4.76E-06	+/- 4.57E-08	8.52E-06	+/- 5.79E-08
2 *	3.39E-06	+/- 3.32E-07	NA	+/- NA	< 4.06E-07	+/- 1.36E-07	3.21E-05	+/- 1.89E-07	5.70E-05	+/- 5.25E-07
3 *	3.84E-06	+/- 6.61E-07	NA	+/- NA	4.33E-07	+/- 1.83E-07	6.85E-05	+/- 4.93E-07	1.26E-04	+/- 1.23E-06
4 *	3.81E-06	+/- 5.80E-07	NA	+/- NA	7.00E-07	+/- 2.28E-07	5.62E-05	+/- 3.54E-07	1.01E-04	+/- 9.02E-07
5 *	3.83E-06	+/- 5.05E-07	NA	+/- NA	< 6.02E-07	+/- 1.72E-07	4.89E-05	+/- 2.64E-07	8.82E-05	+/- 7.32E-07
6 *	5.13E-06	+/- 4.53E-07	NA	+/- NA	5.18E-07	+/- 1.66E-07	3.98E-05	+/- 1.87E-07	7.16E-05	+/- 6.30E-07
7 *	3.81E-06	+/- 5.63E-07	NA	+/- NA	< 3.02E-07	+/- 1.51E-07	3.03E-05	+/- 1.42E-07	5.45E-05	+/- 2.02E-07
8 *	2.87E-05	+/- 2.56E-06	NA	+/- NA	< 1.09E-06	+/- 3.24E-07	9.12E-05	+/- 5.83E-07	1.64E-04	+/- 9.34E-07
9 *	5.92E-05	+/- 2.62E-06	NA	+/- NA	< 1.26E-06	+/- 4.02E-07	5.80E-05	+/- 2.84E-07	1.05E-04	+/- 7.94E-07
10 *	2.42E-05	+/- 6.13E-06	NA	+/- NA	< 8.85E-07	+/- 2.96E-07	3.97E-05	+/- 4.61E-07	7.06E-05	+/- 1.16E-06

Table J-12. Concentrations of radionuclides and stable metals in James A. FitzPatrick mixed-bed resin waste-form leachates: synthetic Barnwell ground water with pH 10.4 (uCi/ml decay corrected to 09/19/88 or ug/ml). (continued)

Sample	Pu-241		Cr		Co		Fe		Ni	
=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
1 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
2 *	NA +/-	NA	< 1.00E-02 +/-	NA	< 5.00E-02 +/-	NA	< 7.50E-02 +/-	NA	< 4.00E-02 +/-	NA
3 *	5.64E-09 +/-	9.02E-09	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
4 *	NA +/-	NA	< 1.00E-02 +/-	NA	< 5.00E-02 +/-	NA	< 7.50E-02 +/-	NA	4.15E-02 +/-	1.37E-02
5 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
6 *	NA +/-	NA	< 1.00E-02 +/-	NA	< 5.00E-02 +/-	NA	< 2.07E-02 +/-	NA	2.96E-02 +/-	9.77E-03
7 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
8 *	NA +/-	NA	< 1.00E-02 +/-	NA	< 5.00E-02 +/-	NA	< 7.50E-02 +/-	NA	8.04E-02 +/-	2.65E-02
9 *	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
10 *	NA +/-	NA	< 1.00E-02 +/-	NA	< 5.00E-02 +/-	NA	< 3.60E-02 +/-	NA	2.22E-02 +/-	7.33E-03

Table J-13. Concentrations of radionuclides and stable metals in James A. FitzPatrick mixed-bed resin waste-form leachates: synthetic Barnwell ground water with pH 4.2 (uCi/ml decay corrected to 09/19/88 or ug/ml).

Sample	Mn-54		Fe-55		Co-58		Co-60		Ni-63	
PR #	2.23E-07	+/- 4.33E-08	NA	+/- NA	3.88E-06	+/- 1.56E-06	2.18E-06	+/- 3.73E-08	NA	+/- NA
1 #	6.43E-06	+/- 9.26E-08	NA	+/- NA	1.78E-05	+/- 2.03E-07	9.72E-05	+/- 1.00E-06	1.50E-05	+/- 8.14E-07
2 #	2.35E-05	+/- 2.28E-07	NA	+/- NA	6.09E-05	+/- 3.90E-07	3.28E-04	+/- 2.82E-06	NA	+/- NA
3 #	2.48E-06	+/- 9.91E-08	NA	+/- NA	6.03E-05	+/- 5.49E-07	3.26E-04	+/- 4.59E-06	1.85E-04	+/- 1.02E-05
4 #	1.43E-06	+/- 1.39E-07	NA	+/- NA	7.73E-05	+/- 8.20E-07	4.15E-04	+/- 4.65E-06	NA	+/- NA
5 #	9.12E-07	+/- 7.02E-08	NA	+/- NA	6.00E-05	+/- 4.44E-07	3.24E-04	+/- 2.63E-06	1.49E-04	+/- 1.00E-05
6 #	1.82E-06	+/- 8.83E-08	NA	+/- NA	5.92E-05	+/- 4.09E-07	3.22E-04	+/- 2.83E-06	NA	+/- NA
7 #	1.98E-06	+/- 8.27E-08	NA	+/- NA	5.23E-05	+/- 5.91E-07	2.84E-04	+/- 2.56E-06	7.64E-05	+/- 4.07E-06
8 #	7.52E-06	+/- 1.81E-07	NA	+/- NA	2.50E-04	+/- 2.25E-06	1.36E-03	+/- 8.81E-06	1.73E-04	+/- 1.20E-05
9 #	4.27E-06	+/- 2.05E-07	NA	+/- NA	3.06E-04	+/- 3.89E-06	1.68E-03	+/- 1.08E-05	NA	+/- NA
10 #	2.13E-05	+/- 3.91E-07	NA	+/- NA	3.38E-04	+/- 1.69E-06	1.83E-03	+/- 1.23E-05	2.24E-05	+/- 2.00E-06

Sample	Zn-65		Sr-90		Sb-125		Cs-134		Cs-137	
PR #	< 1.50E-07	+/- 7.52E-08	NA	+/- NA	< 7.11E-08	+/- 2.38E-08	1.12E-07	+/- 9.03E-09	1.99E-07	+/- 1.11E-08
1 #	3.29E-06	+/- 3.09E-07	NA	+/- NA	< 2.05E-07	+/- 8.95E-08	1.54E-05	+/- 1.06E-07	2.75E-05	+/- 1.95E-07
2 #	1.03E-05	+/- 8.46E-07	NA	+/- NA	< 5.09E-07	+/- 1.60E-07	3.74E-05	+/- 1.38E-07	6.76E-05	+/- 3.65E-07
3 #	3.68E-06	+/- 6.32E-07	NA	+/- NA	< 4.46E-07	+/- 1.96E-07	6.34E-05	+/- 4.44E-07	1.14E-04	+/- 9.80E-07
4 #	4.18E-06	+/- 6.84E-07	NA	+/- NA	< 5.82E-07	+/- 1.91E-07	7.94E-05	+/- 5.32E-07	1.47E-04	+/- 1.38E-06
5 #	3.02E-06	+/- 7.47E-07	NA	+/- NA	< 7.68E-07	+/- 2.11E-07	5.57E-05	+/- 1.95E-07	9.98E-05	+/- 6.39E-07
6 #	3.82E-06	+/- 3.52E-07	NA	+/- NA	5.07E-07	+/- 1.55E-07	4.59E-05	+/- 2.02E-07	8.18E-05	+/- 4.58E-07
7 #	3.44E-06	+/- 6.01E-07	NA	+/- NA	< 3.68E-07	+/- 1.68E-07	3.32E-05	+/- 1.82E-07	5.92E-05	+/- 3.55E-07
8 #	2.01E-05	+/- 2.09E-06	NA	+/- NA	< 1.06E-06	+/- 3.30E-07	1.01E-04	+/- 2.18E-06	1.82E-04	+/- 8.56E-07
9 #	1.94E-05	+/- 3.25E-06	NA	+/- NA	< 7.64E-07	+/- 3.59E-07	6.12E-05	+/- 3.67E-07	1.10E-04	+/- 6.84E-07
10 #	4.95E-05	+/- 3.69E-06	NA	+/- NA	< 1.23E-06	+/- 3.21E-07	3.36E-05	+/- 2.32E-07	6.09E-05	+/- 2.01E-07

Table J-13. Concentrations of radionuclides and stable metals in James A. FitzPatrick mixed-bed resin waste-form leachates: synthetic Barnwell ground water with pH 4.2 (uCi/ml decay corrected to 09/19/88 or ug/ml). (continued)

Sample	Pu-241		Cr		Co		Fe		Ni	
=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
1 #	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
2 #	NA +/-	NA	< 1.00E-02 +/-	NA	< 5.00E-02 +/-	NA	< 1.58E-01 +/-	NA	< 1.78E-02 +/-	NA
3 #	1.92E-08 +/-	9.02E-09	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
4 #	NA +/-	NA	< 1.00E-02 +/-	NA	< 5.00E-02 +/-	NA	< 2.79E-02 +/-	NA	5.28E-02 +/-	1.74E-02
5 #	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
6 #	NA +/-	NA	< 1.00E-02 +/-	NA	< 5.00E-02 +/-	NA	< 7.50E-02 +/-	NA	3.29E-02 +/-	1.09E-02
7 #	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
8 #	NA +/-	NA	< 1.00E-02 +/-	NA	< 5.00E-02 +/-	NA	< 7.50E-02 +/-	NA	8.40E-02 +/-	2.77E-02
9 #	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
10 #	NA +/-	NA	< 1.00E-02 +/-	NA	< 5.00E-02 +/-	NA	< 9.26E-02 +/-	NA	3.47E-02 +/-	1.15E-02

Table J-14. Concentrations of radionuclides and stable metals in James A. FitzPatrick mixed-bed resin waste-form leachates: synthetic Hanford ground water with pH 8.9 (uCi/ml decay corrected to 09/19/88 or ug/ml).

Sample	Mn-54		Fe-55		Co-58		Co-60		Ni-63	
PR *	2.48E-06	+/- 1.21E-07	NA	+/- NA	< 8.93E-06	+/- 4.46E-06	9.52E-06	+/- 1.37E-07	NA	+/- NA
1 *	8.84E-07	+/- 1.08E-07	NA	+/- NA	7.91E-06	+/- 1.55E-07	4.12E-05	+/- 4.08E-07	5.29E-06	+/- 3.05E-07
2 *	2.02E-06	+/- 5.38E-08	3.32E-06	+/- 2.21E-07	2.69E-05	+/- 2.12E-07	1.45E-04	+/- 1.59E-06	7.30E-05	+/- 4.00E-06
3 *	8.75E-07	+/- 6.75E-08	NA	+/- NA	5.67E-05	+/- 4.37E-07	3.04E-04	+/- 3.41E-06	1.60E-04	+/- 9.16E-06
4 *	4.62E-07	+/- 6.77E-08	4.87E-06	+/- 7.80E-08	4.71E-05	+/- 6.40E-07	2.57E-04	+/- 3.72E-06	2.10E-04	+/- 1.20E-05
5 *	2.75E-07	+/- 8.29E-08	NA	+/- NA	4.58E-05	+/- 3.71E-07	2.53E-04	+/- 2.48E-06	NA	+/- NA
6 *	1.55E-06	+/- 7.40E-08	1.72E-06	+/- 1.26E-07	3.76E-05	+/- 4.66E-07	2.02E-04	+/- 1.78E-06	9.70E-05	+/- 6.00E-06
7 *	8.62E-07	+/- 6.61E-08	NA	+/- NA	3.60E-05	+/- 3.60E-07	1.93E-04	+/- 2.07E-06	8.86E-05	+/- 5.09E-06
8 *	2.26E-06	+/- 1.73E-07	1.72E-06	+/- 4.74E-07	1.90E-04	+/- 1.02E-06	1.03E-03	+/- 6.48E-06	1.90E-04	+/- 1.10E-05
9 *	1.59E-06	+/- 1.91E-07	NA	+/- NA	2.24E-04	+/- 2.24E-06	1.22E-03	+/- 8.19E-06	NA	+/- NA
10 *	1.85E-06	+/- 1.70E-07	6.61E-06	+/- 1.16E-07	2.59E-04	+/- 1.53E-06	1.41E-03	+/- 9.05E-06	1.21E-04	+/- 8.00E-06

Sample	Zn-65		Sr-90		Sb-125		Cs-134		Cs-137	
PR *	< 4.95E-07	+/- 2.16E-07	NA	+/- NA	< 2.01E-07	+/- 6.82E-08	1.74E-07	+/- 2.49E-08	2.08E-07	+/- 2.41E-08
1 *	2.30E-07	+/- 9.36E-08	NA	+/- NA	< 1.38E-07	+/- 5.96E-08	7.41E-06	+/- 6.89E-08	1.34E-05	+/- 7.12E-08
2 *	1.88E-06	+/- 1.82E-07	NA	+/- NA	< 3.47E-07	+/- 1.09E-07	2.92E-05	+/- 1.08E-07	5.25E-05	+/- 3.46E-07
3 *	9.52E-07	+/- 2.17E-07	NA	+/- NA	< 4.16E-07	+/- 1.69E-07	6.93E-05	+/- 4.23E-07	1.27E-04	+/- 8.36E-07
4 *	7.52E-07	+/- 2.44E-07	NA	+/- NA	< 5.96E-07	+/- 1.93E-07	6.18E-05	+/- 3.09E-07	1.10E-04	+/- 1.02E-06
5 *	8.41E-07	+/- 2.76E-07	NA	+/- NA	< 4.09E-07	+/- 2.05E-07	5.10E-05	+/- 3.26E-07	9.31E-05	+/- 9.59E-07
6 *	1.17E-06	+/- 1.79E-07	NA	+/- NA	< 6.16E-07	+/- 1.84E-07	3.44E-05	+/- 1.96E-07	6.20E-05	+/- 4.52E-07
7 *	9.70E-07	+/- 1.96E-07	NA	+/- NA	< 4.87E-07	+/- 1.83E-07	2.90E-05	+/- 2.11E-07	5.15E-05	+/- 4.48E-07
8 *	7.10E-06	+/- 1.47E-06	NA	+/- NA	< 6.04E-07	+/- 2.96E-07	1.07E-04	+/- 5.26E-07	1.93E-04	+/- 1.21E-06
9 *	1.01E-05	+/- 2.16E-06	NA	+/- NA	< 6.45E-07	+/- 3.23E-07	7.99E-05	+/- 5.43E-07	1.44E-04	+/- 1.04E-06
10 *	1.39E-05	+/- 2.92E-06	NA	+/- NA	< 6.00E-07	+/- 2.92E-07	4.85E-05	+/- 2.67E-07	8.68E-05	+/- 3.47E-07

Table J-14. Concentrations of radionuclides and stable metals in James A. FitzPatrick mixed-bed resin waste-form leachates: synthetic Hanford ground water with pH 8.9 (uCi/ml decay correct to 09/19/88 or ug/ml). (continued)

Sample	Pu-241		Cr		Co		Fe		Ni	
=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
1 #	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
2 #	NA +/-	NA	< 1.00E-02 +/-	NA	< 5.00E-02 +/-	NA	< 7.50E-02 +/-	NA	< 4.00E-02 +/-	NA
3 #	3.38E-09 +/-	6.77E-09	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
4 #	NA +/-	NA	< 1.00E-02 +/-	NA	< 5.00E-02 +/-	NA	< 7.50E-02 +/-	NA	3.47E-02 +/-	1.15E-02
5 #	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
6 #	NA +/-	NA	< 1.00E-02 +/-	NA	< 5.00E-02 +/-	NA	< 1.00E-01 +/-	NA	2.25E-02 +/-	7.42E-03
7 #	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
8 #	NA +/-	NA	< 1.00E-02 +/-	NA	< 5.00E-02 +/-	NA	< 7.50E-02 +/-	NA	9.18E-02 +/-	3.03E-02
9 #	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
10 #	NA +/-	NA	< 1.00E-02 +/-	NA	< 5.00E-02 +/-	NA	< 7.50E-02 +/-	NA	4.22E-02 +/-	1.39E-02

Table J-15. Concentrations of radionuclides and stable metals in James A. FitzPatrick mixed-bed resin waste-form leachates: synthetic seawater with pH 6.4 (uCi/ml decay corrected to 09/19/88 or ug/ml).

Sample	Mn-54		Fe-55		Co-58		Co-60		Ni-63	
PR *	1.97E-07 +/-	2.61E-08	NA +/-	NA	< 5.06E-06 +/-	1.73E-06	1.63E-06 +/-	3.18E-08	NA +/-	NA
1 *	2.14E-07 +/-	3.05E-08	NA +/-	NA	1.17E-05 +/-	1.91E-07	6.34E-05 +/-	8.81E-07	3.05E-06 +/-	2.04E-07
2 *	6.67E-07 +/-	8.04E-08	NA +/-	NA	6.27E-05 +/-	1.00E-06	3.38E-04 +/-	3.62E-06	NA +/-	NA
3 *	5.11E-07 +/-	8.55E-08	NA +/-	NA	8.47E-05 +/-	6.60E-07	4.55E-04 +/-	4.65E-06	1.04E-04 +/-	5.09E-06
4 *	3.72E-07 +/-	8.50E-08	NA +/-	NA	5.98E-05 +/-	8.31E-07	3.22E-04 +/-	4.45E-06	NA +/-	NA
5 *	3.39E-07 +/-	8.38E-08	NA +/-	NA	4.69E-05 +/-	5.77E-07	2.53E-04 +/-	3.32E-06	4.48E-05 +/-	3.00E-06
6 *	< 1.48E-07 +/-	7.41E-08	NA +/-	NA	4.11E-05 +/-	9.36E-07	2.26E-04 +/-	4.85E-06	NA +/-	NA
7 *	2.60E-07 +/-	8.28E-08	NA +/-	NA	3.54E-05 +/-	6.02E-07	1.97E-04 +/-	1.75E-06	3.26E-05 +/-	2.04E-06
8 *	< 6.85E-07 +/-	2.29E-07	NA +/-	NA	3.15E-04 +/-	2.11E-06	1.71E-03 +/-	9.93E-06	NA +/-	NA
9 *	< 5.76E-07 +/-	2.88E-07	NA +/-	NA	3.98E-04 +/-	4.58E-06	2.20E-03 +/-	1.91E-05	NA +/-	NA
10 *	< 7.06E-07 +/-	2.24E-07	NA +/-	NA	3.24E-04 +/-	4.41E-05	1.92E-03 +/-	2.02E-05	3.87E-04 +/-	3.00E-05

Sample	Zn-65		Sr-90		Sb-125		Cs-134		Cs-137	
PR *	< 1.52E-07 +/-	7.60E-08	NA +/-	NA	< 5.76E-08 +/-	2.87E-08	1.43E-07 +/-	1.23E-08	2.12E-07 +/-	1.41E-08
1 *	2.53E-07 +/-	8.86E-08	NA +/-	NA	< 1.64E-07 +/-	8.13E-08	7.38E-06 +/-	4.50E-08	1.34E-05 +/-	1.07E-07
2 *	1.02E-06 +/-	2.26E-07	NA +/-	NA	4.06E-07 +/-	1.65E-07	5.22E-05 +/-	1.98E-07	9.36E-05 +/-	4.02E-07
3 *	3.04E-06 +/-	4.98E-07	NA +/-	NA	< 6.74E-07 +/-	1.83E-07	6.35E-05 +/-	3.81E-07	1.14E-04 +/-	7.87E-07
4 *	5.84E-07 +/-	2.64E-07	NA +/-	NA	< 2.96E-07 +/-	1.48E-07	3.62E-05 +/-	3.04E-07	6.57E-05 +/-	8.01E-07
5 *	9.30E-07 +/-	2.09E-07	NA +/-	NA	< 3.79E-07 +/-	1.64E-07	2.35E-05 +/-	1.83E-07	4.24E-05 +/-	3.81E-07
6 *	4.65E-07 +/-	2.17E-07	NA +/-	NA	< 2.51E-07 +/-	1.26E-07	1.80E-05 +/-	2.36E-07	3.21E-05 +/-	7.95E-07
7 *	< 8.37E-07 +/-	2.26E-07	NA +/-	NA	< 3.21E-07 +/-	1.30E-07	1.64E-05 +/-	8.84E-08	2.92E-05 +/-	2.10E-07
8 *	3.31E-06 +/-	1.25E-06	NA +/-	NA	< 8.81E-07 +/-	3.77E-07	1.48E-04 +/-	6.50E-07	2.64E-04 +/-	1.32E-06
9 *	1.88E-05 +/-	4.99E-06	NA +/-	NA	< 6.54E-07 +/-	3.27E-07	1.75E-04 +/-	9.63E-07	3.12E-04 +/-	3.40E-06
10 *	1.84E-05 +/-	5.20E-06	NA +/-	NA	< 1.00E-06 +/-	5.00E-07	1.05E-04 +/-	6.94E-07	1.88E-04 +/-	2.09E-06

Table J-15. Concentrations of radionuclides and stable metals in James A. FitzPatrick mixed-bed resin waste-form leachates: synthetic seawater with pH 6.4 (uCi/ml decay corrected to 09/19/88 or ug/ml). (continued)

Sample	Pu-241		Cr		Co		Fe		Ni	
*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
1 #	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
2 #	NA +/-	NA	< 1.00E-02 +/-	NA	< 5.00E-02 +/-	NA	< 7.50E-02 +/-	NA	< 2.70E-02 +/-	NA
3 #	3.95E-08 +/-	1.02E-08	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
4 #	NA +/-	NA	< 1.00E-02 +/-	NA	< 5.00E-02 +/-	NA	< 7.50E-02 +/-	NA	< 4.00E-02 +/-	NA
5 #	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
6 #	NA +/-	NA	< 1.00E-02 +/-	NA	< 5.00E-02 +/-	NA	< 7.50E-02 +/-	NA	< 4.00E-02 +/-	NA
7 #	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
8 #	NA +/-	NA	< 1.00E-02 +/-	NA	< 5.00E-02 +/-	NA	< 7.50E-02 +/-	NA	1.03E-01 +/-	3.40E-02
9 #	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
10 #	NA +/-	NA	< 1.00E-02 +/-	NA	< 5.00E-02 +/-	NA	< 7.50E-02 +/-	NA	1.13E-01 +/-	3.73E-02

Table J-16. Concentrations of radionuclides and stable metals in baked James A. FitzPatrick mixed-bed resin waste-form leachates: deionized water (uCi/ml decay corrected to 09/19/88 or ug/ml).

Sample	Mn-54		Fe-55		Co-58		Co-60		Ni-63	
PR #	NA +\-	NA	NA +\-	NA	< 4.82E-06 +\-	1.61E-06	2.27E-06 +\-	3.54E-08	NA +\-	NA
1 *	1.69E-05 +\-	2.18E-07	NA +\-	NA	5.05E-05 +\-	6.56E-07	2.72E-04 +\-	2.20E-06	4.48E-05 +\-	2.04E-06
2 *	2.43E-05 +\-	3.53E-07	NA +\-	NA	9.51E-05 +\-	8.18E-07	5.15E-04 +\-	3.40E-06	2.44E-04 +\-	1.32E-05
3 *	6.79E-06 +\-	1.15E-07	NA +\-	NA	1.28E-04 +\-	1.19E-06	6.93E-04 +\-	4.78E-06	2.44E-04 +\-	1.32E-05
4 *	1.36E-05 +\-	2.40E-07	NA +\-	NA	1.28E-04 +\-	1.57E-06	6.83E-04 +\-	7.71E-06	1.61E-04 +\-	9.16E-06
5 *	1.47E-05 +\-	1.33E-07	NA +\-	NA	1.12E-04 +\-	1.24E-06	6.16E-04 +\-	4.37E-06	1.40E-04 +\-	7.13E-06
6 *	1.80E-06 +\-	1.73E-07	NA +\-	NA	1.01E-04 +\-	2.46E-06	5.54E-04 +\-	8.41E-06	9.37E-05 +\-	5.09E-06
7 *	2.21E-05 +\-	2.30E-07	NA +\-	NA	9.42E-05 +\-	1.26E-06	5.10E-04 +\-	3.98E-06	8.65E-05 +\-	5.09E-06
8 *	1.63E-05 +\-	2.44E-07	NA +\-	NA	2.58E-04 +\-	4.17E-06	1.41E-03 +\-	1.65E-05	2.24E-04 +\-	1.22E-05
9 *	2.35E-06 +\-	2.67E-07	NA +\-	NA	2.70E-04 +\-	3.56E-04	1.47E-03 +\-	1.37E-03	1.21E-04 +\-	6.11E-06
10 *	7.80E-07 +\-	2.18E-07	NA +\-	NA	3.05E-04 +\-	3.01E-05	1.66E-03 +\-	1.84E-05	7.94E-05 +\-	4.07E-06
11 *	< 5.11E-07 +\-	1.43E-07	NA +\-	NA	2.47E-04 +\-	4.05E-06	1.37E-03 +\-	1.92E-05	NA +\-	NA
12 *	< 5.92E-07 +\-	1.86E-07	NA +\-	NA	1.56E-04 +\-	1.92E-06	8.52E-04 +\-	6.99E-06	NA +\-	NA
13 *	3.28E-06 +\-	5.73E-07	NA +\-	NA	3.03E-04 +\-	2.43E-05	1.36E-03 +\-	1.00E-05	NA +\-	NA

Sample	Zn-65		Sr-90		Sb-125		Cs-134		Cs-137	
PR #	1.63E-07 +\-	7.41E-08	NA +\-	NA	< 7.72E-08 +\-	2.90E-08	1.94E-07 +\-	1.12E-08	3.14E-07 +\-	1.29E-08
1 *	4.52E-06 +\-	4.24E-07	NA +\-	NA	< 8.52E-07 +\-	2.30E-07	4.43E-05 +\-	2.48E-07	8.01E-05 +\-	5.29E-07
2 *	8.48E-06 +\-	9.00E-07	NA +\-	NA	5.32E-07 +\-	1.95E-07	8.03E-05 +\-	4.66E-07	1.49E-04 +\-	7.72E-07
3 *	5.70E-06 +\-	1.12E-06	NA +\-	NA	< 8.06E-07 +\-	2.64E-07	1.01E-04 +\-	5.54E-07	1.88E-04 +\-	8.84E-07
4 *	6.65E-06 +\-	1.16E-06	NA +\-	NA	< 8.84E-07 +\-	2.29E-07	7.88E-05 +\-	5.35E-07	1.42E-04 +\-	1.27E-06
5 *	7.43E-06 +\-	1.17E-06	NA +\-	NA	5.53E-07 +\-	1.90E-07	5.16E-05 +\-	2.73E-07	9.28E-05 +\-	6.77E-07
6 *	5.33E-06 +\-	1.55E-06	NA +\-	NA	< 4.32E-07 +\-	2.14E-07	3.70E-05 +\-	3.81E-07	6.65E-05 +\-	1.42E-06
7 *	7.39E-06 +\-	9.13E-07	NA +\-	NA	5.22E-07 +\-	1.86E-07	2.49E-05 +\-	1.70E-07	4.48E-05 +\-	2.20E-07
8 *	1.63E-05 +\-	4.16E-06	NA +\-	NA	8.82E-07 +\-	2.64E-07	5.61E-05 +\-	5.33E-07	9.98E-05 +\-	1.82E-06
9 *	1.56E-05 +\-	4.08E-06	NA +\-	NA	< 6.02E-07 +\-	3.01E-07	4.07E-05 +\-	3.38E-05	7.32E-05 +\-	9.59E-07
10 *	1.58E-05 +\-	4.07E-06	NA +\-	NA	< 5.82E-07 +\-	2.91E-07	2.79E-05 +\-	4.95E-07	4.96E-05 +\-	7.88E-07
11 *	1.49E-05 +\-	4.00E-06	NA +\-	NA	4.18E-07 +\-	1.31E-07	1.56E-05 +\-	1.78E-07	2.41E-05 +\-	2.79E-06
12 *	2.92E-06 +\-	8.02E-07	NA +\-	NA	6.23E-07 +\-	1.95E-07	7.26E-06 +\-	9.37E-08	1.33E-05 +\-	2.34E-07
13 *	9.64E-06 +\-	2.53E-06	NA +\-	NA	< 7.14E-07 +\-	3.57E-07	7.07E-06 +\-	1.25E-07	1.30E-05 +\-	1.51E-07

Table J-16. Concentrations of radionuclides and stable metals in baked James A. FitzPatrick mixed-bed resin waste-form leachates: deionized water (uCi/ml decay corrected to 09/19/88 or ug/ml). (continued)

Sample	Pu-241		Cr		Co		Fe		Ni	
=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
1 #	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
2 #	NA +/-	NA	< 1.00E-02 +/-	NA	< 5.00E-02 +/-	NA	< 7.50E-02 +/-	NA	4.65E-02 +/-	1.53E-02
3 #	4.29E-08 +/-	1.02E-08	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
4 #	NA +/-	NA	< 1.00E-02 +/-	NA	< 5.00E-02 +/-	NA	3.85E-02 +/-	1.27E-02	7.65E-02 +/-	2.52E-02
5 #	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
6 #	NA +/-	NA	< 1.00E-02 +/-	NA	< 5.00E-02 +/-	NA	2.70E-02 +/-	8.91E-03	4.76E-02 +/-	1.57E-02
7 #	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
8 #	NA +/-	NA	< 1.00E-02 +/-	NA	< 5.00E-02 +/-	NA	1.85E-02 +/-	6.10E-03	5.28E-02 +/-	1.74E-02
9 #	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
10 #	NA +/-	NA	< 1.00E-02 +/-	NA	< 5.00E-02 +/-	NA	< 7.50E-02 +/-	NA	3.38E-02 +/-	1.12E-02

Table J-17. Concentrations of radionuclides and stable metals in baked James A. FitzPatrick mixed-bed resin waste-form leachates: synthetic Barnwell ground water with pH 4.2 ($\mu\text{Ci}/\text{ml}$ decay corrected to 09/19/88 or $\mu\text{g}/\text{ml}$).

Sample	Mn-54		Fe-55		Co-58		Co-60		Ni-63	
PR *	1.96E-07	+/- 2.30E-08	NA	+/- NA	4.74E-06	+/- 1.70E-06	1.95E-06	+/- 2.93E-08	NA	+/- NA
1 *	1.98E-05	+/- 1.82E-07	NA	+/- NA	3.83E-05	+/- 4.75E-07	2.04E-04	+/- 1.73E-06	2.55E-05	+/- 2.04E-06
2 *	3.38E-05	+/- 5.74E-07	NA	+/- NA	8.22E-05	+/- 1.02E-06	4.35E-04	+/- 5.70E-06	NA	+/- NA
3 *	4.63E-06	+/- 1.01E-07	NA	+/- NA	8.55E-05	+/- 7.27E-07	4.61E-04	+/- 4.52E-06	2.14E-04	+/- 1.12E-05
4 *	2.19E-06	+/- 9.78E-08	NA	+/- NA	1.14E-04	+/- 1.91E-06	6.23E-04	+/- 7.91E-06	NA	+/- NA
5 *	5.16E-06	+/- 9.44E-08	NA	+/- NA	7.30E-05	+/- 7.88E-07	3.96E-04	+/- 3.40E-06	1.63E-04	+/- 1.10E-05
6 *	4.81E-07	+/- 9.01E-08	NA	+/- NA	6.70E-05	+/- 1.24E-06	3.69E-04	+/- 5.16E-06	NA	+/- NA
7 *	6.12E-06	+/- 1.09E-07	NA	+/- NA	7.31E-05	+/- 5.27E-07	3.94E-04	+/- 3.12E-06	7.23E-05	+/- 4.07E-06
8 *	7.11E-05	+/- 4.27E-07	NA	+/- NA	2.74E-04	+/- 2.96E-06	1.49E-03	+/- 8.64E-06	1.63E-04	+/- 1.10E-05
9 *	2.16E-05	+/- 9.70E-01	NA	+/- NA	2.60E-04	+/- 5.60E-06	1.42E-03	+/- 8.64E-06	NA	+/- NA
10 *	1.51E-05	+/- 2.74E-07	NA	+/- NA	2.89E-04	+/- 2.57E-06	1.57E-03	+/- 1.02E-05	1.03E-04	+/- 7.00E-06

Sample	Zn-65		Sr-90		Sb-125		Cs-134		Cs-137	
PR *	1.72E-07	+/- 7.70E-08	NA	+/- NA	< 4.60E-08	+/- 2.30E-08	1.30E-07	+/- 8.98E-09	1.96E-07	+/- 1.18E-08
1 *	7.93E-06	+/- 4.38E-07	NA	+/- NA	5.04E-07	+/- 1.21E-07	2.33E-05	+/- 1.07E-07	4.19E-05	+/- 2.56E-07
2 *	1.62E-05	+/- 1.09E-06	NA	+/- NA	8.52E-07	+/- 1.34E-07	4.20E-05	+/- 2.23E-07	7.53E-05	+/- 4.29E-07
3 *	6.42E-06	+/- 9.53E-07	NA	+/- NA	4.05E-07	+/- 1.99E-07	7.36E-05	+/- 3.53E-07	1.32E-04	+/- 8.34E-07
4 *	7.01E-06	+/- 1.60E-06	NA	+/- NA	< 3.99E-07	+/- 1.26E-07	9.29E-05	+/- 6.13E-07	1.67E-04	+/- 2.03E-06
5 *	7.88E-06	+/- 6.44E-07	NA	+/- NA	4.73E-07	+/- 1.66E-07	4.85E-05	+/- 2.42E-07	8.70E-05	+/- 6.27E-07
6 *	4.06E-06	+/- 1.01E-06	NA	+/- NA	< 6.28E-07	+/- 1.66E-07	3.93E-05	+/- 3.81E-07	7.05E-05	+/- 1.30E-06
7 *	9.87E-06	+/- 6.69E-07	NA	+/- NA	< 5.51E-07	+/- 1.74E-07	3.03E-05	+/- 2.27E-07	5.54E-05	+/- 3.99E-07
8 *	1.11E-04	+/- 3.74E-06	NA	+/- NA	< 1.84E-06	+/- 4.70E-07	7.51E-05	+/- 3.61E-07	1.35E-04	+/- 6.50E-07
9 *	4.91E-05	+/- 3.12E-06	NA	+/- NA	< 1.68E-06	+/- 5.40E-07	5.12E-05	+/- 2.92E-07	9.19E-05	+/- 4.41E-07
10 *	4.40E-05	+/- 3.47E-06	NA	+/- NA	< 7.76E-07	+/- 3.01E-07	3.29E-07	+/- 2.14E-09	5.91E-05	+/- 3.54E-07

Table J-17. Concentrations of radionuclides and stable metals in baked James A. FitzPatrick mixed-bed resin waste-form leachates: synthetic Barnwell ground water with pH 4.2 (uCi/ml decay corrected to 09/19/88 or ug/ml). (continued)

Sample	Pu-241		Cr		Co		Fe		Ni	
*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
1 #	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
2 #	NA +/-	NA	< 1.00E-02 +/-	NA	< 5.00E-02 +/-	NA	< 7.40E-02 +/-	NA	1.56E-02 +/-	5.15E-03
3 #	1.69E-08 +/-	9.02E-09	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
4 #	NA +/-	NA	< 1.00E-02 +/-	NA	< 5.00E-02 +/-	NA	4.77E-02 +/-	1.57E-02	5.87E-02 +/-	1.94E-02
5 #	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
6 #	NA +/-	NA	< 6.40E-03 +/-	NA	< 5.00E-02 +/-	NA	< 7.50E-02 +/-	NA	1.96E-02 +/-	6.47E-03
7 #	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
8 #	NA +/-	NA	< 1.00E-02 +/-	NA	< 5.00E-02 +/-	NA	5.67E-02 +/-	1.87E-02	4.86E-02 +/-	1.60E-02
9 #	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA	NA +/-	NA
10 #	NA +/-	NA	< 1.00E-02 +/-	NA	< 5.00E-02 +/-	NA	< 3.60E-02 +/-	NA	1.94E-02 +/-	6.40E-03

APPENDIX K

CONCENTRATIONS OF CHELATING AGENTS IN LEACHATES

APPENDIX K

CONCENTRATIONS OF CHELATING AGENTS IN LEACHATES

Concentrations of citric and oxalic acids in leachates generated during testing of five Brunswick Unit 1 mixed-bed resin waste-form specimens are given in Table K-1. Concentrations of picolinic acid in leachates generated during testing of seven mixed-bed resin waste-form specimens obtained from the James A. FitzPatrick Station are given in Table K-2. The data in Appendix K was used to compute the data located in Appendix I.

Table K-1. Concentrations of sulfate and citric and oxalic acids in Brunswick-1 mixed-bed resin waste-form leachates (ug/ml).

Deionized water:

Sample	Sulfate	Oxalic Acid	Citric Acid
1*	2.66E+00 +/- 5.01E-01	8.21E-01 +/- 5.55E-01	1.54E+00 +/- 3.44E-01
2*	2.77E+00 +/- 7.04E-01	1.04E+00 +/- 5.86E-01	1.04E+00 +/- 4.53E-01
3*	1.95E+00 +/- 6.55E-01	9.02E-01 +/- 6.05E-01	9.69E-01 +/- 4.66E-01
4*	1.44E+00 +/- 6.39E-01	7.85E-01 +/- 5.85E-01	9.80E-01 +/- 4.79E-01
5*	5.93E+00 +/- 7.60E-01	8.11E-01 +/- 5.93E-01	2.22E+00 +/- 5.81E-01
6*	2.90E+00 +/- 7.53E-01	7.99E-01 +/- 6.42E-01	1.26E+00 +/- 5.17E-01
7*	1.07E+00 +/- 6.25E-01	7.65E-01 +/- 6.38E-01	6.37E-01 +/- 4.53E-01
8*	9.76E-01 +/- 6.19E-01	8.51E-01 +/- 5.91E-01	7.04E-01 +/- 4.33E-01
9*	2.61E+00 +/- 7.56E-01	8.92E-01 +/- 5.62E-01	7.35E-01 +/- 4.53E-01
10*	2.00E+00 +/- 6.60E-01	8.99E-01 +/- 6.05E-01	8.14E-01 +/- 4.11E-01

Synthetic Barnwell ground water with pH 10.4:

Sample	Sulfate	Oxalic Acid	Citric Acid
1*	2.81E+00 +/- 6.02E-01	1.09E+00 +/- 4.70E-01	1.35E+00 +/- 4.36E-01
2*	3.33E+00 +/- 7.24E-01	1.12E+00 +/- 6.45E-01	1.06E+00 +/- 4.89E-01
3*	2.80E+00 +/- 6.66E-01	8.21E-01 +/- 6.45E-01	9.67E-01 +/- 4.69E-01
4*	3.34E+00 +/- 6.37E-01	7.65E-01 +/- 6.38E-01	8.72E-01 +/- 4.55E-01
5*	3.86E+00 +/- 7.11E-01	7.69E-01 +/- 6.40E-01	9.14E-01 +/- 4.79E-01
6*	4.80E+00 +/- 7.79E-01	8.16E-01 +/- 6.75E-01	7.48E-01 +/- 5.03E-01
7*	4.51E+00 +/- 7.07E-01	7.56E-01 +/- 6.33E-01	5.71E-01 +/- 4.33E-01
8*	3.32E+00 +/- 7.19E-01	7.71E-01 +/- 6.22E-01	5.75E-01 +/- 4.74E-01
9*	1.88E+00 +/- 7.38E-01	8.76E-01 +/- 6.08E-01	6.59E-01 +/- 4.23E-01
10*	1.24E+00 +/- 6.43E-01	7.56E-01 +/- 6.33E-01	7.02E-01 +/- 4.69E-01

Synthetic Barnwell ground water with pH 4.2:

Sample	Sulfate	Oxalic Acid	Citric Acid
1*	1.62E+01 +/- 7.24E-01	2.45E+00 +/- 5.90E-01	3.52E+00 +/- 5.54E-01
2*	1.45E+01 +/- 1.07E+00	1.91E+00 +/- 7.27E-01	2.62E+00 +/- 5.97E-01
3*	1.11E+01 +/- 9.84E-01	1.42E+00 +/- 6.52E-01	1.48E+00 +/- 5.48E-01
4*	8.52E+00 +/- 6.66E-01	9.74E-01 +/- 6.35E-01	1.77E+00 +/- 5.74E-01
5*	7.88E+00 +/- 6.98E-01	9.54E-01 +/- 6.65E-01	1.81E+00 +/- 5.89E-01
6*	8.77E+00 +/- 9.95E-01	9.71E-01 +/- 6.56E-01	1.82E+00 +/- 5.81E-01
7*	7.21E+00 +/- 6.63E-01	8.64E-01 +/- 6.90E-01	1.23E+00 +/- 4.69E-01
8*	8.68E+00 +/- 2.10E-01	9.49E-01 +/- 6.90E-01	2.25E+00 +/- 7.31E-01
9*	7.16E+00 +/- 2.10E-01	9.28E-01 +/- 2.18E-01	3.20E+00 +/- 7.51E-02
10*	6.14E+00 +/- 2.10E-01	8.42E-01 +/- 2.18E-01	2.97E+00 +/- 7.51E-02

Synthetic Hanford ground water with pH 8.9:

Sample	Sulfate	Oxalic Acid	Citric Acid
1*	3.62E+01 +/- 2.14E+00	1.28E+00 +/- 6.39E-01	3.17E+00 +/- 5.13E-01
2*	1.08E+01 +/- 8.72E-01	1.42E+00 +/- 6.20E-01	1.11E+00 +/- 4.63E-01
3*	1.09E+01 +/- 1.21E+00	1.10E+00 +/- 6.13E-01	1.06E+00 +/- 5.35E-01
4*	8.44E+00 +/- 8.23E-01	8.21E-01 +/- 6.45E-01	7.70E-01 +/- 4.42E-01
5*	9.26E+00 +/- 1.16E+00	7.99E-01 +/- 6.56E-01	7.15E-01 +/- 5.26E-01
6*	8.02E+00 +/- 8.17E-01	8.42E-01 +/- 6.79E-01	6.48E-01 +/- 5.26E-01
7*	7.46E+00 +/- 7.49E-01	7.74E-01 +/- 6.42E-01	5.16E-01 +/- 4.79E-01
8*	9.01E+00 +/- 6.62E-01	9.28E-01 +/- 6.79E-01	6.82E-01 +/- 4.54E-01
9*	9.92E+00 +/- 7.83E-01	1.07E+00 +/- 6.52E-01	1.08E+00 +/- 4.54E-01
10*	9.37E+00 +/- 2.10E-01	1.03E+00 +/- 2.18E-01	2.91E+00 +/- 7.51E-02

Table K-1. Concentrations of sulfate and citric and oxalic acids in Brunswick-1 mixed-bed resin waste-form leachates (ug/ml). (continued)

Synthetic seawater with pH 6.4:

Sample	Sulfate	Oxalic Acid	Citric Acid
1*	1.42E+01 +/- 8.69E-01	6.92E-01 +/- 5.74E-01	1.08E+00 +/- 4.62E-01
2*	1.96E+01 +/- 2.10E-01	NA +/- NA	NA +/- NA
3*	2.04E+01 +/- 2.10E-01	5.85E-01 +/- 2.18E-01	5.49E-01 +/- 7.51E-02
4*	2.49E+01 +/- 2.10E-01	NA +/- NA	7.48E-01 +/- 7.51E-02
5*	2.38E+01 +/- 2.10E-01	NA +/- NA	1.21E+00 +/- 7.51E-02
6*	2.22E+01 +/- 2.10E-01	NA +/- NA	NA +/- NA
7*	2.43E+01 +/- 2.10E-01	NA +/- NA	7.21E-01 +/- 7.51E-02
8*	2.16E+01 +/- 2.10E-01	NA +/- NA	1.48E+00 +/- 7.51E-02
9*	1.63E+01 +/- 2.10E-01	NA +/- NA	8.14E-01 +/- 7.51E-02
10*	1.43E+01 +/- 2.10E-01	NA +/- NA	6.42E-01 +/- 7.51E-02

Table K-2. Concentration of picolinic acid in James A FitzPatrick mixed-bed resin waste-form leachates (ug/ml).

Unbaked waste-form specimens:

Sample	Deionized Water	Synthetic Barnwell ground water with pH 10.4	Synthetic Barnwell ground water with pH 4.2
PR	1.04E+01 +/- 1.04E+00	1.10E+01 +/- 1.10E+00	1.23E+01 +/- 1.23E+00
1*	1.04E+01 +/- 1.04E+00	1.12E+01 +/- 1.12E+00	1.26E+01 +/- 1.26E+00
2*	6.20E+01 +/- 6.20E+00	1.36E+01 +/- 1.36E+00	1.60E+01 +/- 1.60E+00
3*	1.45E+01 +/- 1.45E+00	1.83E+02 +/- 1.83E+01	1.25E+02 +/- 1.25E+01
4*	1.76E+02 +/- 1.76E+01	1.25E+01 +/- 1.25E+00	2.63E+01 +/- 2.63E+00
5*	4.25E+01 +/- 4.25E+00	1.76E+02 +/- 1.76E+01	2.55E+01 +/- 2.55E+00
6*	4.79E+01 +/- 4.79E+00	5.29E+01 +/- 5.29E+00	9.14E+01 +/- 9.14E+00
7*	1.35E+02 +/- 1.35E+01	1.74E+01 +/- 1.74E+00	3.10E+01 +/- 3.10E+00
8*	2.77E+02 +/- 2.77E+01	4.52E+02 +/- 4.52E+01	3.06E+01 +/- 3.06E+00
9*	1.86E+02 +/- 1.86E+01	2.75E+02 +/- 2.75E+01	2.73E+02 +/- 2.73E+01
10*	1.52E+02 +/- 1.52E+01	7.50E+01 +/- 7.50E+00	8.80E+01 +/- 8.80E+00
11*	7.15E+01 +/- 7.15E+00	NA +/- NA	NA +/- NA
12*	2.13E+01 +/- 2.13E+00	NA +/- NA	NA +/- NA

Sample	Synthetic Hanford ground water with pH 8.9	Synthetic seawater with pH 6.4
PR	1.06E+01 +/- 1.06E+00	1.30E+01 +/- 1.30E+00
1*	1.09E+01 +/- 1.09E+00	8.33E+00 +/- 8.33E-01
2*	2.32E+01 +/- 2.32E+00	1.47E+01 +/- 1.47E+00
3*	1.89E+01 +/- 1.89E+00	2.96E+01 +/- 2.96E+00
4*	1.40E+01 +/- 1.40E+00	1.78E+01 +/- 1.78E+00
5*	2.01E+01 +/- 2.01E+00	1.13E+01 +/- 1.13E+00
6*	1.30E+01 +/- 1.30E+00	9.91E+00 +/- 9.91E-01
7*	1.08E+01 +/- 1.08E+00	1.05E+01 +/- 1.05E+00
8*	1.62E+01 +/- 1.62E+00	8.52E+01 +/- 8.52E+00
9*	3.18E+02 +/- 3.18E+01	NA +/- NA
10*	3.37E+02 +/- 3.37E+01	NA +/- NA
11*	4.14E+01 +/- 4.14E+00	NA +/- NA
12*	NA +/- NA	NA +/- NA

Baked waste-form specimens:

Sample	Deionized Water	Synthetic Barnwell ground water with pH 4.2
PR	1.03E+01 +/- 1.03E+00	1.26E+01 +/- 1.26E+00
1*	3.29E+01 +/- 3.29E+00	1.28E+01 +/- 1.28E+00
2*	2.15E+02 +/- 2.15E+01	1.78E+01 +/- 1.78E+00
3*	2.57E+02 +/- 2.57E+01	1.25E+01 +/- 1.25E+00
4*	6.66E+01 +/- 6.66E+00	8.76E+01 +/- 8.76E+00
5*	1.92E+02 +/- 1.92E+01	4.79E+01 +/- 4.79E+00
6*	3.01E+01 +/- 3.01E+00	2.08E+01 +/- 2.08E+00
7*	3.18E+01 +/- 3.18E+00	3.21E+01 +/- 3.21E+00
8*	2.67E+02 +/- 2.67E+01	3.98E+02 +/- 3.98E+01
9*	1.35E+02 +/- 1.35E+01	7.62E+01 +/- 7.62E+00
10*	2.54E+02 +/- 2.54E+01	4.34E+02 +/- 4.34E+01
11*	1.73E+02 +/- 1.73E+01	NA +/- NA
12*	2.73E+01 +/- 2.73E+00	NA +/- NA

APPENDIX L

QUANTITIES OF RADIONUCLIDES, METALS, AND CHELATING AGENTS SOLIDIFIED IN EACH LINER

THE UNIVERSITY OF CHICAGO
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540 EAST 57TH STREET
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APPENDIX L

QUANTITIES OF RADIONUCLIDES, METALS, AND CHELATING AGENTS SOLIDIFIED IN EACH LINER

The total activities solidified in each of the three liners are given in Table L-1, and the total quantities of metals and chelating agents solidified in each liner are given in Table L-2.

Table B-1. Total activity solidified in each liner
(Ci/liner decay-corrected to sample collection date)

Brunswick-1						
Nuclide	Cation		Mixed-bed		FitzPatrick	
Cr-51	ND		ND		1.45E+00 +/- 1.69E-01	
Mn-54	2.11E+00 +/- 1.34E-02		7.83E-02 +/- 4.63E-04		4.19E+00 +/- 2.30E-02	
Fe-55	1.12E+01 +/- 9.30E-01		5.17E-01 +/- 4.34E-02		2.28E-01 +/- 2.96E-03	
Fe-59	< 2.49E-01		< 4.01E-02		1.58E+00 +/- 1.04E-02	
Co-57	ND		ND		1.75E-02 +/- 6.86E-04	
Co-58	2.17E-01 +/- 2.66E-02		1.03E-02 +/- 1.78E-03		4.37E+00 +/- 2.26E-02	
Co-60	1.05E+01 +/- 1.38E-01		4.84E-01 +/- 2.40E-03		1.65E+01 +/- 1.65E-03	
Ni-63	2.04E+00 +/- 7.76E-02		1.53E-01 +/- 8.33E-03		5.64E-01 +/- 2.96E-02	
Zn-65	1.40E-01 +/- 2.45E-02		7.00E-03 +/- 1.40E-03		9.79E-01 +/- 2.62E-02	
Sr-90	5.72E-03 +/- 3.78E-04		2.89E-03 +/- 1.62E-04		2.54E-04 +/- 2.06E-05	
Zr-95	< 5.92E-02		< 1.84E-02		2.16E-02 +/- 2.04E-03	
Nb-95	ND		ND		4.71E-02 +/- 3.88E-03	
Sn-113	ND		ND		2.40E-02 +/- 2.31E-03	
Sb-125	5.09E-03 +/- 8.16E-04		1.86E-02 +/- 1.18E-04		3.60E-02 +/- 2.30E-03	
Cs-134	< 1.27E-03		< 2.57E-04		3.23E-02 +/- 8.99E-04	
Cs-137	5.57E-02 +/- 6.62E-04		1.34E-03 +/- 4.02E-05		6.59E-02 +/- 1.77E-03	
Subtotal:	2.66E+01 +/- 9.44E-01		1.33E+00 +/- 4.43E-02		3.01E+01 +/- 1.77E-01	
Pu-238	1.03E-06 +/- 6.42E-08	(a)	2.82E-07 +/- 2.25E-08	(a)	8.40E-05 +/- 2.10E-06	
Pu-239	8.07E-07 +/- 5.15E-08		2.48E-07 +/- 2.14E-08		1.50E-04 +/- 2.58E-06	
Pu-241	8.20E-03 +/- 6.28E-04		7.34E-03 +/- 5.76E-04		2.25E-01 +/- 1.72E-02	
Am-241	---		---		1.26E-04 +/- 2.25E-06	
Cm-242	-4.65E-08 +/- 7.79E-08		1.15E-07 +/- 7.01E-08		1.38E-04 +/- 2.69E-06	
Cm-244	1.02E-07 +/- 2.00E-08		1.86E-08 +/- 9.66E-09		1.45E-05 +/- 4.03E-07	
Subtotal:	8.20E-03 +/- 6.28E-04		7.34E-03 +/- 5.76E-04		2.26E-01 +/- 1.72E-02	
	m ³	ft ³	m ³	ft ³	m ³	ft ³
Waste volume:	3.40	120	3.11	110	3.03	107
Liner type:	L14-170	L14-170	L14-170	L14-170	L14-170	L14-170
Liner capacity:	4.79	169	4.79	169	4.79	169

(a) Pu-238 and/or Am-241. Pu-238 and Am-241 in the Brunswick-1 cation and mixed-bed resins were not separated prior to analysis by alpha spectrometry.

Table B-2. Total quantities of metals and chelating agents solidified in each liner (kg/liner)

Metal	Brunswick-1		
	Cation	Mixed-bed	FitzPatrick
Chromium	1.79E+00 +/- 6.32E-02	6.27E+00 +/- 2.22E-01	7.76E-01 +/- 2.74E-02
Iron	2.55E+01 +/- 7.33E-01	2.74E+00 +/- 5.81E-02	9.49E+00 +/- 2.01E-01
Cobalt	8.28E-01 +/- 2.28E-02	1.18E+00 +/- 2.55E-02	1.02E+00 +/- 2.28E-02
Nickel	2.89E+00 +/- 1.02E-01	2.56E-01 +/- 5.72E-02	4.61E-01 +/- 1.63E-02
Subtotal:	3.10E+01 +/- 7.43E-01	1.04E+01 +/- 2.38E-01	1.17E+01 +/- 2.05E-01
Acid			
Citric	(a)	1.63E+02 +/- 1.63E+01	(a)
Oxalic	(a)	7.96E+01 +/- 7.96E+00	(a)
Picolinic	(a)	(a)	8.75E+01 +/- 8.75E+00
Subtotal:	NA	2.43E+02 +/- 1.81E+01	8.75E+01 +/- 8.75E+00

(a) Concentration of acid in resin waste was not determined. Picolinic acid was not expected to be present in the Brunswick-1 resin wastes and citric and oxalic acids were not expected to be present in the FitzPatrick resin waste at measurable concentrations.