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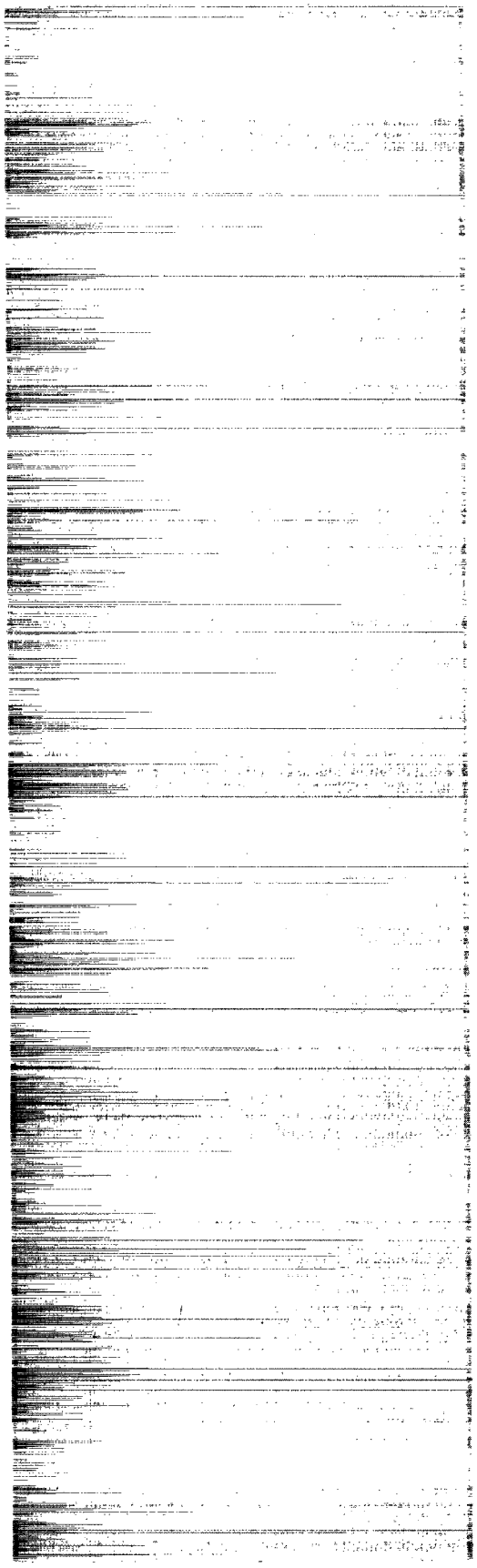

Batch Sorption Results for Neptunium Transport through Yucca Mountain Tuffs

Yucca Mountain Site Characterization Program Milestone 3349

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Yucca Mountain Site Characterization Project Milestone 3349

by

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ABSTRACT

We studied the sorption of neptunium onto tuffs characteristic of the proposed nuclear waste repository at Yucca Mountain, Nevada. The neptunium was in the Np(V) oxidation state under oxidizing conditions in groundwaters from two wells located close to the repository site (J-13 and UE-25 p#1). We used devitrified, vitric, zeolitic (with emphasis on clinoptilolite-rich samples), and calcite-rich tuffs characteristic of the geology of the site. Neptunium sorbed well onto calcite and calcite-rich tuffs, indicating that a significant amount of neptunium retardation can be expected under fractured-flow scenarios because of calcite coating of the fractures. Neptunium sorption onto clinoptilolite-rich zeolitic tuffs in J-13 well water (pH from 7 to 8.5) was moderate, increased with decreasing pH, and correlated to surface area and amount of clinoptilolite. Neptunium sorbed poorly onto zeolitic tuffs from UE-25 p#1 groundwater (pH from 7 to 9) and onto devitrified and vitric tuffs from J-13 and UE-25 p#1 waters (pH from 7 to 9). Iron oxides appeared to be passivated in tuffs, not seeming to contribute to the observed neptunium sorption, even though neptunium sorption onto synthetic iron oxide is significant.

INTRODUCTION

The transport of ^{237}Np through tuffs is of major importance in assessing the performance of a potential high-level nuclear waste repository at Yucca Mountain. Uranium in nuclear reactors produces ^{237}Np, which has a half-life of 2.14×10^6 years. Nitsche et al. (1993 and 1994) reported that neptunium has a higher solubility in groundwaters from Yucca Mountain than do other actinides (such as plutonium and americium). The high solubility of neptunium combined with its extremely limited sorption onto Yucca Mountain tuffs (Thomas 1987) makes this radionuclide a high priority in the sorption studies conducted as part of the Yucca Mountain Site Characterization Project. The strategy for obtaining neptunium sorption data for use in performance assessment calculations, as defined by Meijer (1992), is to

- perform sorption studies with pure minerals and tuff samples;
- identify the minerals and groundwater chemistry most critical to the sorption behavior of neptunium;
- bound the variations in the most critical parameters to neptunium sorption (using site-specific data);
- generate probability distributions for the most

critical parameters; and

- generate probability distributions for the neptunium sorption distribution coefficients (K_d) that will be used in performance assessment calculations.

To identify the dominant sorptive minerals in the tuffs of Yucca Mountain and the effect of water chemistry variations on their sorption of neptunium, we performed batch sorption experiments using pure mineral separates and tuffs and groundwaters from the site. As part of this effort, we generated a neptunium sorption database for submission to the Yucca Mountain Project Technical Data Base.

EXPERIMENTAL PROCEDURES

Groundwaters

For these experiments, we used groundwaters from Wells J-13 and UE-25 p#1 because the chemistry of these waters seem to bound that of the Yucca Mountain groundwaters (Meijer 1992). The chemistry of these two groundwaters is given in Appendix A and summarized in Figs. 1 and 2. Both are basically sodium bicarbonate waters. Other cations are calcium, potassium, and magnesium; other anions are sulfate, chloride, nitrate, and fluoride; and the other major constituent is silica. The ionic strength of UE-25 p#1 water is higher than that of J-13 water. Because both waters are oxidizing (Ogard and Kerrisk1984), we performed

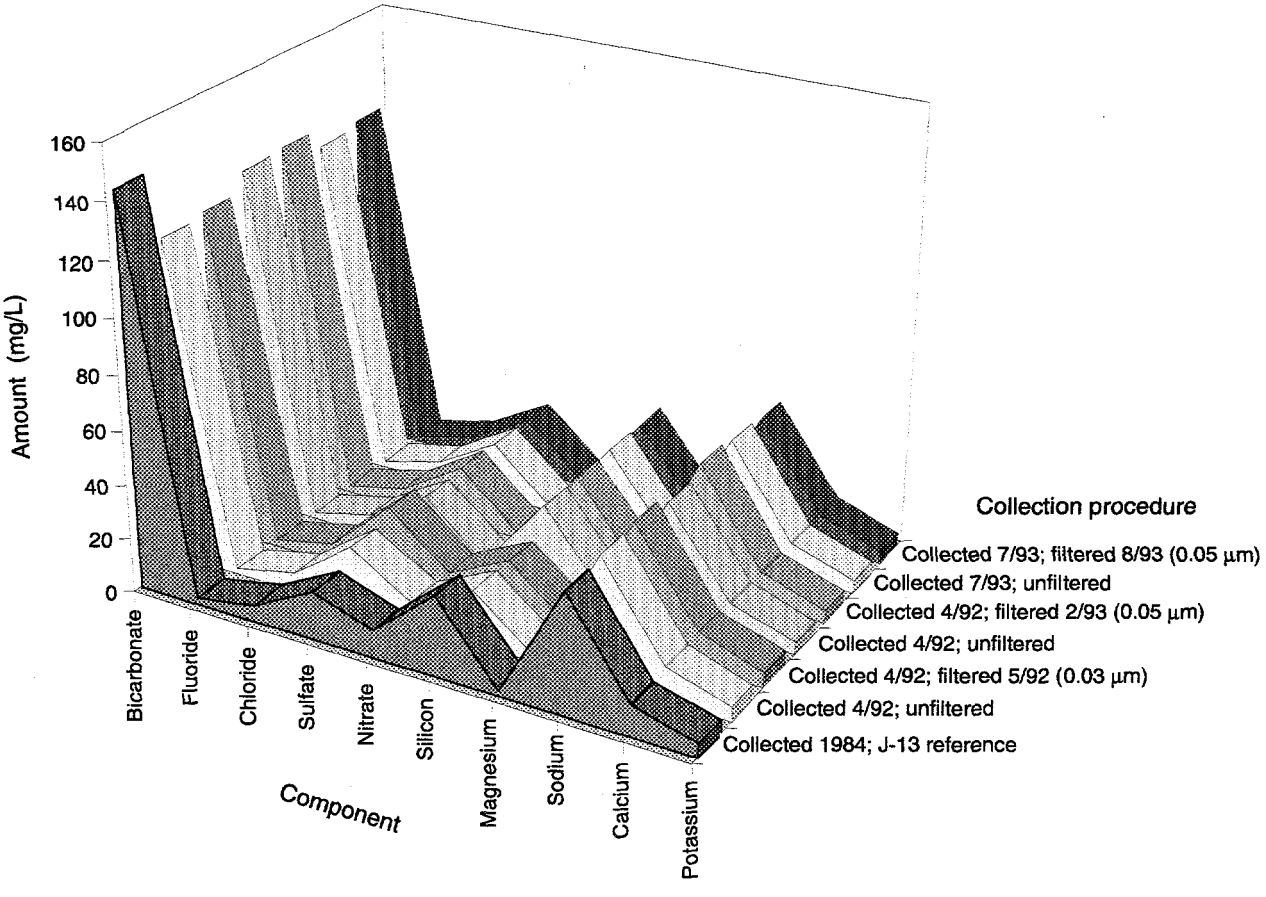

Figure 1. J-13 Well Water. This chemical analysis of water from Well J-13 shows minimal compositional changes as a function of collection date and whether or not it was filtered. No apparent calcite precipitation occurred during transport to or while being stored at Los Alamos.

all the batch sorption experiments under oxidizing conditions.

The J-13 and UE-25 p#1 reference data plotted in Figs. 1 and 2 were obtained on site by Ogard and Kerrisk (1984). This on-site chemistry is compared in the figures with the chemistry of aliquots of J-13 and UE-25 p#1 waters that were collected at later dates and sent to Los Alamos National Laboratory. Because both groundwaters were filtered through a 0.05-μm filter prior to their use in the sorption experiments, the water chemistry of aliquots of the groundwaters before and after filtration is also compared in the figures. The data indicate that filtration does not cause compositional changes in the water.

The pH of the on-site J-13 and UE-25 p#1 waters is ~7; after they are equilibrated with the atmosphere at Los Alamos, the pH of the J-13 water increases to 8.5 and the pH of UE-25 p#1 water increases to ~9. The reason for the increase is CO_2 evolution.

The chemistry of the water from the Well J-13 seems to be very stable over the period from 1984 to the present (see Appendix A). No changes seem to occur due to CO_2 evolution and filtration (Fig. 1). However, the data of Fig. 2 indicate that CO_2 evolution in UE-25 p#1 water causes a decrease in both bicarbonate and calcium concentrations, which implies calcite precipitation. Consequently, the concentration of bicarbonate and

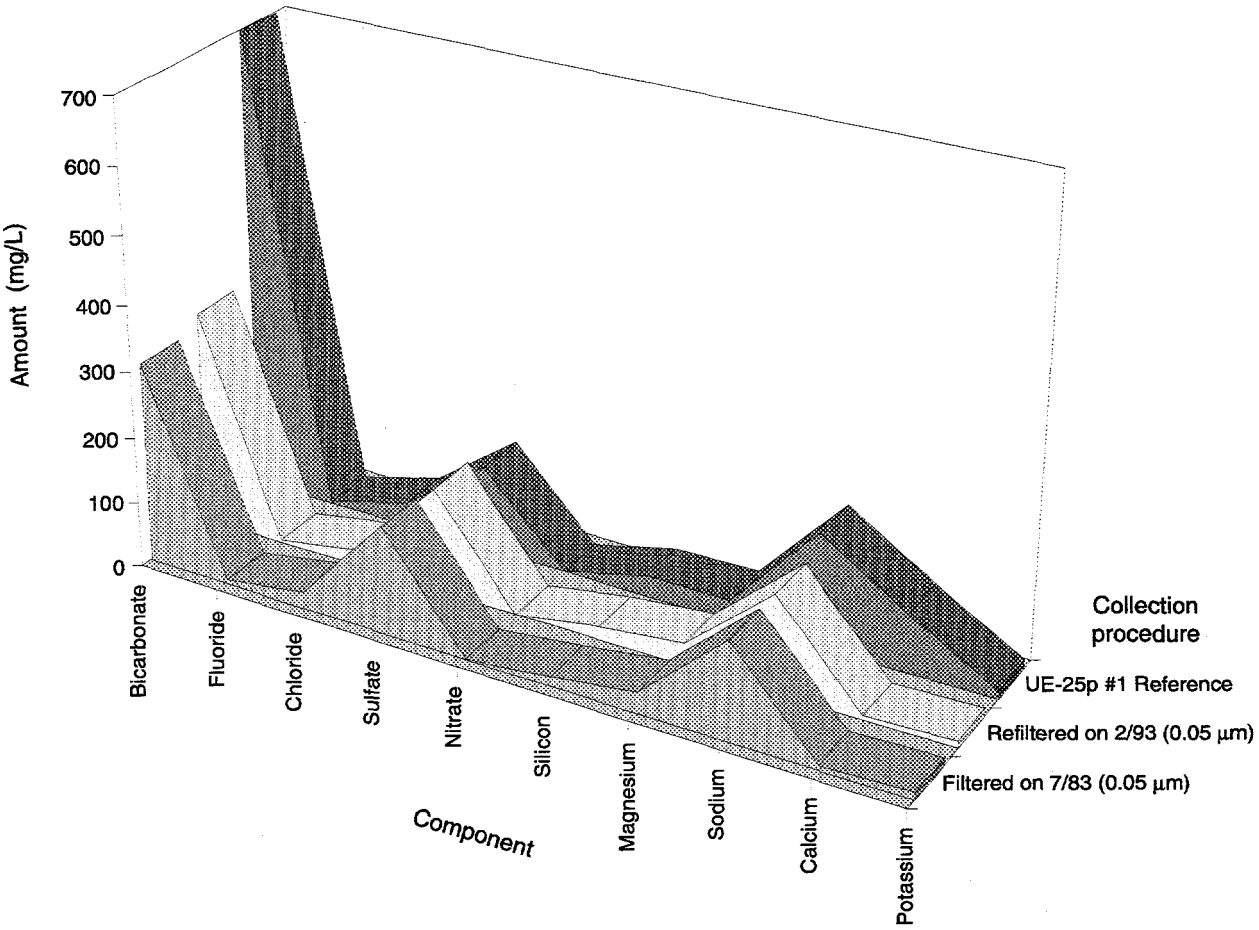

Figure 2. UE-25 p#1 Well Water. This chemical analysis of water from Well UE-25 p#1 shows apparent calcite precipitation after collection but then minimal compositional changes thereafter.

calcium in the UE-25 p#1 water used in the sorption experiments at Los Alamos is lower than the concentration of these constituents in the UE-25 p#1 water at the site.

Minerals and Tuff Samples

The minerals used for the neptunium batch sorption experiments (reported in Appendix B) are synthetic calcite, calcite, synthetic hematite, montmorillonite, bentonite, clinoptilolite, quartz, and albite. The synthetic calcite and hematite were commercially available $CaCO_3$ and Fe_2O_3, respectively. The origin of the natural minerals is given in Table 1.

The tuff samples used for sorption experiments were obtained from drill holes at Yucca Mountain at the specified depth (in feet). For instance, the designation G4-270 refers to a tuff sample obtained from drill hole USW G-4 at a depth of 270 feet. The locations of the drill holes used has been reported by Bish and Chipera (1989).

The mineralogy, determined by x-ray-diffraction (XRD) analysis, and surface area, determined by BET (Brunauer, Emmett, and Teller) analysis, of the solids used in the sorption experiments are given in Appendix C. The details of the XRD data used to determine the mineralogy of the samples was previously reported (Bish and Chipera 1989; Chipera and Bish 1989 and 1994). The data indicate that the minerals used were over 95% pure.

The following types of tuff samples were characterized by XRD and BET analysis:

- pieces of uncrushed tuff referred to as "not ground,"
- crushed tuff dry-sieved to obtain particles in a given size range,
- crushed tuff wet-sieved with water from Well J-13 to obtain particles in a given size range, and
- crushed tuff wet-sieved with water from Well UE-25 p#1 to obtain particles in a given size range.

Details of the procedure used for crushing and sieving samples are given in LANL-CST-DP-63, R4, *Yucca Mountain Project Detailed Procedures*, Los Alamos National Laboratory. Data of Appendix C indicate that crushing and sieving the tuff samples does not cause significant differences in the mineralogy of the tuff. In several cases, sieving the samples to eliminate particles smaller that 75 μm appears to reduce the smectite content of the tuff samples. Because smectite is a good sorber for most radionuclides, the sieved tuff samples (with particle sizes in the range from 75 to 500

Table 1. Natural Minerals for Sorption Experiments

Sample ID Code	Description	Origin
B	Natural calcite	Iceland Spar Outcrop, Chihuahua, Mexico
D-1	Montmorillonite	Cheto, Arizona
G	Purified clinoptilolite	Castle Creek, Idaho
M	Quartz	Hot Springs, Arkansas
O	Bentonite	Cerro Blanco (from GSA Resources, Inc., Cortaro, Arizona)
P	Albite	Unknown

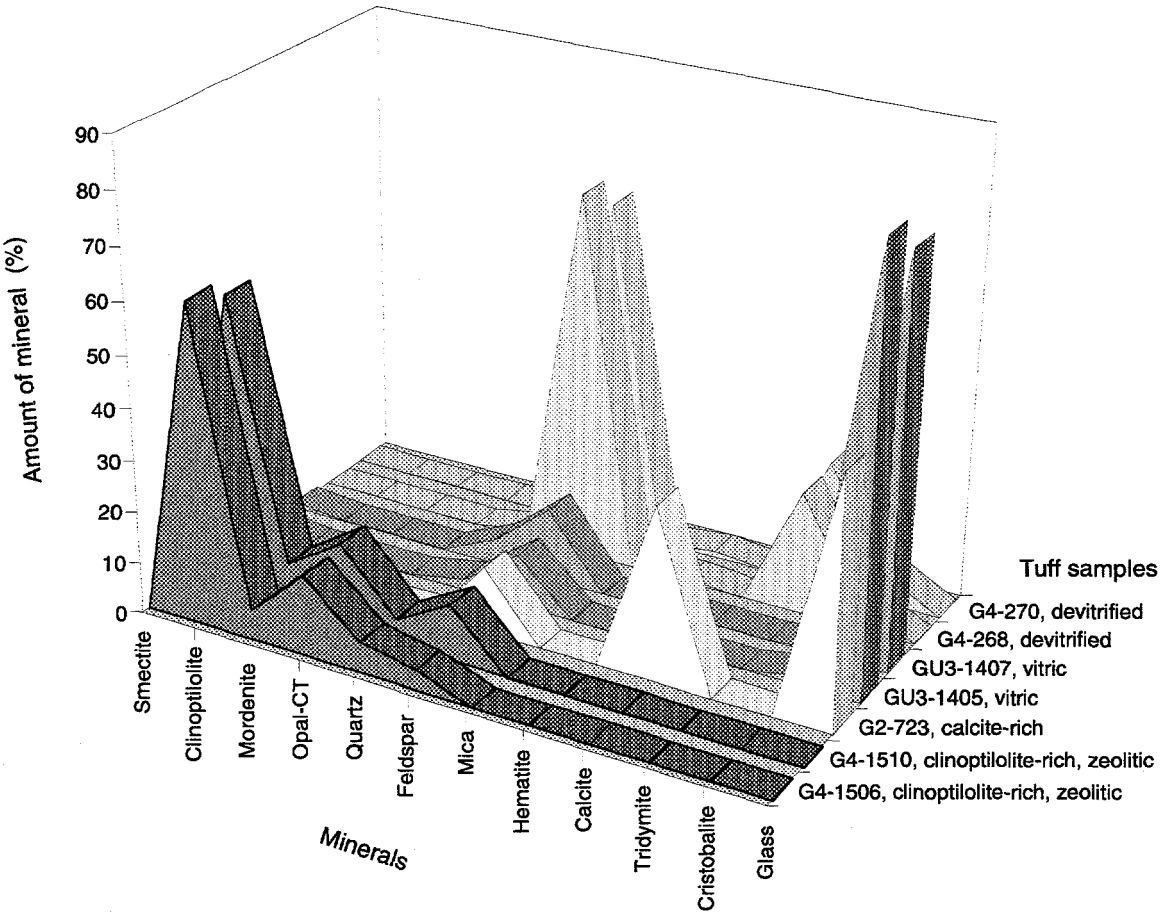

Figure 3. X-ray Diffraction Results. Mineral percentages determined by x-ray diffraction for the tuffs used in the sorption experiments. Each tuff, except GU3-1405, was wet-sieved with J-13 well water to particle sizes ranging from 75 to 500 micrometers.

μm) yield conservative sorption results.

The three major rock types used for sorption experiments were zeolitic, vitric, and devitrified. Figure 3 summarizes the mineralogy of tuff samples representative of each major rock type. The zeolitic tuffs are represented by samples G4-1506 and G4-1510; the major component of these tuffs is clinoptilolite. The vitric tuffs are represented by samples GU3-1405 and GU3-1407; the major component of these tuffs is glass. The devitrified tuffs are represented by samples G4-268 and G4-270; the major component of these tuffs is alkali feldspar. Figure 3 also shows the mineralogy of tuff G2-723, which has a high calcite content. Figure 4 gives the surface area of representative tuffs and minerals. All the zeolitic tuffs studied have surface areas larger than 18 m^2/g.

Neptunium Solutions

The neptunium solutions used for the batch sorption experiments were prepared by taking an aliquot of a well-characterized $^{237}Np(V)$ acidic stock and diluting it in the groundwater being studied. Nitsche et al. (1993 and 1994) reported the solubility and speciation of neptunium in J-13 and UE-25 p#1 waters at room temperature at pH values of 7 and 8.5. These data are summarized in Table 2.

Batch Sorption Procedure

All batch sorption experiments reported in

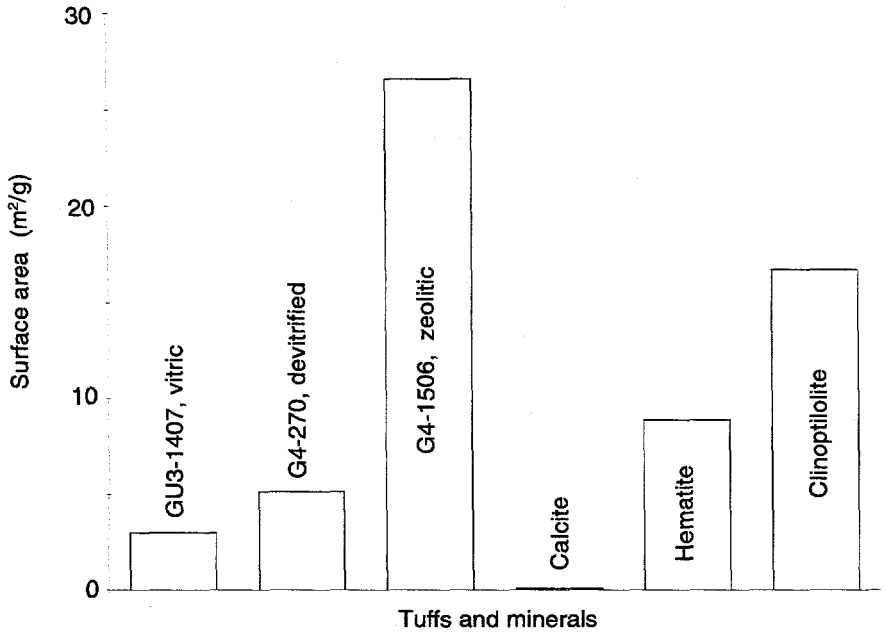

Figure 4. Surface Areas of Tuffs and Minerals. BET analysis was used to determine the surface areas of the tuffs and minerals used in the sorption experiments. The tuffs and the calcite were wet-sieved with J-13 well water to obtain particle sizes ranging from 75 to 500 μm. The synthetic hematite and clinoptilolite were not sieved.

Appendix B were performed at room temperature. The procedure first involved pretreating the solid phase with the groundwater being studied—from either Well J-13 or UE-25 p#1—in the ratio of 1 g of solid to 20 mL of solution. The pretreated solid phase was then separated from the groundwater by centrifugation and equilibrated with 20 mL of a neptunium solution (in the groundwater being studied). After sorption, the phases were separated by centrifugation. The amount of ^{237}Np in solution initially and after sorption was determined with a liquid scintillation counter (Packard tri-carb 2550-TR/AB). The amount of ^{237}Np in the solid phase was determined by difference. The liquid scintillation counting technique used can discriminate alpha activity from beta activity; consequently no interference from ^{233}Pa (the daughter of ^{237}Np) is expected. Because the efficiency of this liquid scintillation counter is approximately 100%, the counts per minute (cpm) reported in Appendix B are approximately equivalent to disintegrations per minute. We used containers without solid phases (control tubes) to monitor neptunium precipitation and sorption onto the container walls during the sorption experiment. The difference in the concentration of neptunium in the initial solution and in the control tube varied from −2% to 7%.

Table 2. Speciation of $^{237}Np(V)$ in Groundwaters*

Water	pH	Solubility (M)	NpO_2^+	$NpO_2CO_3^-$
J-13	7	1.3×10^{-4}	46%	54%
	8.5	4.4×10^{-5}	38%	62%
UE-25 p#1	7	4.7×10^{-4}	63%	37%
	8.5	7.0×10^{-6}	N/A	N/A

*From Nitsche et al. 1993 and 1994

The batch sorption distribution coefficient, K_d, was calculated using

$$K_d = \frac{\text{moles of radionuclide per g of solid phase}}{\text{moles of radionuclide per mL of solution}}, \quad [1]$$

and thus has units of mL/g.

We performed the batch sorption experiments

under atmospheric conditions and inside glove boxes with a CO_2 overpressure. The pH of the J-13 and UE-25 p#1 waters under atmospheric conditions was approximately 8.5 and 9, respectively, and inside the glove boxes was 7 (the CO_2 overpressure was adjusted to bring the pH of both waters down to 7). References describing the details of the experimental setup and analytical techniques that we used in the sorption experiments are given in Table 3.

Determination of very small or very large batch sorption distribution coefficients results in large uncertainties in the K_d values calculated. When very little sorption occurs, calculations can yield negative K_d values; the error results from subtracting two large numbers (the initial neptunium concentration in solution and the neptunium concentration after sorption) to obtain a small number (the amount of neptunium in the solid phase). Therefore, small K_d values (in the range of ± 1) are not significant. When a great deal of sorption occurs, calculations can yield large uncertainties associated with measuring the small amount of radioactivity left in solution after sorption. Because neptunium sorption distribution coefficients tend to be very small, most K_d values are only reported to one significant figure.

Table 3. Procedures for Sorption Experiments

Procedure	Reference*
Batch sorption (under atmospheric conditions)	LANL-CST-DP-86
Batch sorption (within the controlled atmosphere of a glove box)	LANL-CST-DP-100
pH measurement	LANL-CST-DP-35
Eh measurement	LANL-CST-DP-102
Liquid scintillation counting	LANL-CST-DP-79

**Yucca Mountain Project Detailed Procedures*, Los Alamos National Laboratory

RESULTS AND DISCUSSION

We investigated sorption as a function of sieving procedure for devitrified (G4-270) and zeolitic (G4-1506) tuffs in J-13 and UE-25 p#1 well waters. Data presented in Fig. 5 indicate that wet-sieving probably eliminates small particles that cause artificially high K_d values. As previously determined by Rogers and Chipera (1994), the optimal batch sorption procedure involves wet-sieving the tuff samples to a size of 75 to 500 μm. Figure 6 illustrates the problem that could arise when sorption experiments are performed with pure minerals consisting of very finely divided particles that cannot be wet-sieved. The neptunium batch sorption coefficients determined vary by more than an order of magnitude between the dry- and the wet-sieved natural calcite. The potential differences in surface area and particle size between a pure mineral and that same mineral in the tuff samples may make predictions of sorption behavior on whole rock impossible when the basis of those predictions is pure mineral work. As illustrated in Fig. 6, the trends in sorption as a function of concentration and groundwater chemistry stay the same regardless of whether dry- or wet-sieved calcite is used. Consequently, the most effective use of pure mineral sorption data is the identification of trends in the sorptive behavior of a mineral. Figures 5 and 6 also illustrate the effect of water chemistry on neptunium sorption; for example, the sorption of neptunium onto zeolitic tuffs decreases considerably with the increasing carbonate content and ionic strength of the UE-25 p#1 water. The reverse trend is observed for calcite samples.

We investigated the kinetics of neptunium sorption onto tuffs and pure minerals and found that the sorption of neptunium onto tuffs and clinoptilolite appears to be fast (Fig. 7). No significant differences are observed in neptunium sorption as a function of time for the tuffs studied and for clinoptilolite. This is not the case for pure miner-

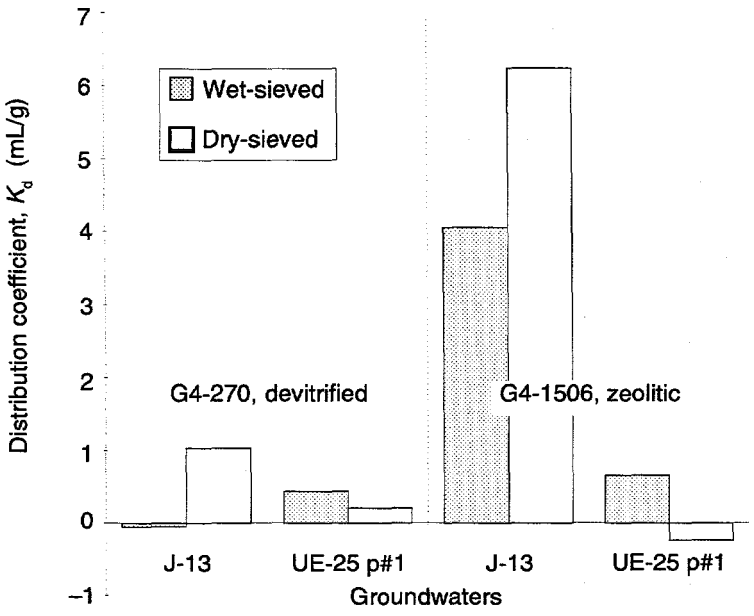

Figure 5. Neptunium Sorption for Wet- and Dry-sieved Tuffs. Experimental values of the batch sorption distribution coefficient, K_d, are shown for sorption of neptunium onto tuff (under atmospheric conditions) that allow comparisons of both groundwaters (J-13 and UE-25 p#1), two types of tuff (devitrified and zeolitic), and wet- or dry-sieving to particle sizes ranging from 75 to 500 μm. The initial neptunium concentration was 1×10^{-6} M. The pretreatment period with the two groundwaters was 13 to 15 days; the neptunium sorption period was 21 to 22 days.

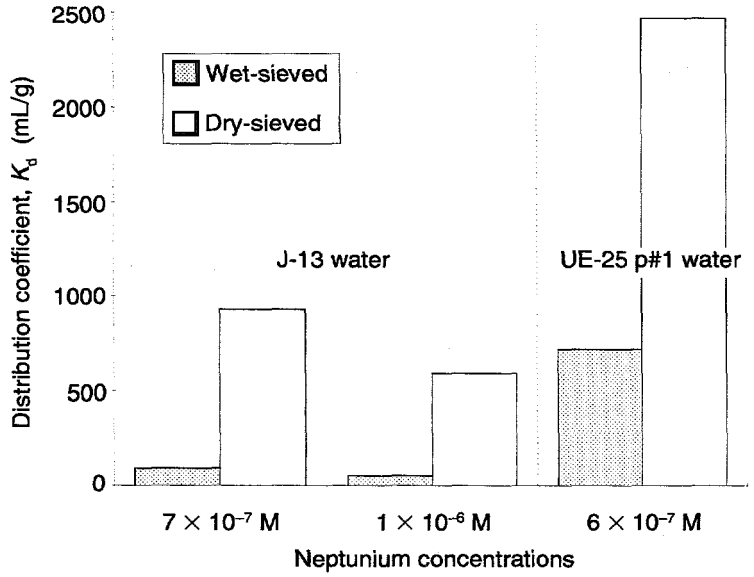

Figure 6. Neptunium Sorption for Wet- and Dry-sieved Calcite. Experimental values of the batch sorption distribution coefficient, K_d, are given for sorption of neptunium onto calcite (under atmospheric conditions) that allow comparisons of both groundwaters (J-13 and UE-25 p#1), different initial concentrations of neptunium, and wet- or dry-sieving to particle sizes ranging from 75 to 500 μm. The pretreatment period was 14 to 15 days; the sorption period was 17 to 24 days.

als that tend to sorb by means of a coprecipitation mechanism (such as calcite) or by surface complexation (such as hematite). Figures 8 and 9 show the sorption dependence on time for calcite and hematite in waters from the Wells J-13 and UE-25 p#1. The dissolution/precipitation reactions that may accompany the coprecipitation of neptunium with calcite may be slow compared with other sorption mechanisms. Future experiments will address this issue by monitoring the chemistry of the groundwater as it is being equilibrated with these minerals.

We investigated the dependence of neptunium sorption on pH in J-13 water. Figures 10 and 11 show that for vitric tuffs (such as samples G2-767 and GU3-1407), pH does not seem to make a significant difference in the amount of neptunium sorption measured. Samples G2-1813, G2-1951, G2-2000, and G2-2222 are zeolitic tuffs. Until the

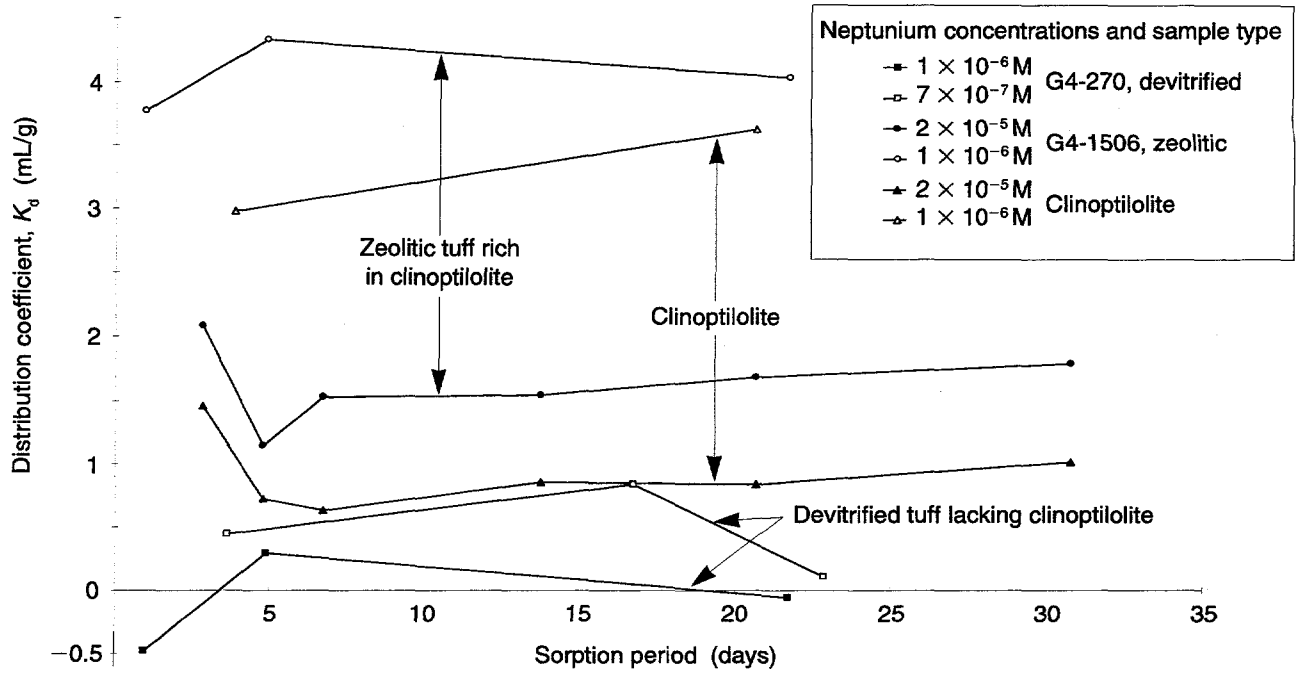

Figure 7. Time Dependence of Neptunium Sorption for Tuffs and Clinoptilolite. Variation with time of K_d for sorption of neptunium onto devitrified tuff (G4-270) lacking clinoptilolite (squares), zeolitic tuff (G4-1506) rich in clinoptilolite (circles), and pure clinoptilolite (triangles) under atmospheric conditions and at the specified initial neptunium concentrations in J-13 well water. Tuffs were wet-sieved to particle sizes from 75 to 500 μm; the clinoptilolite was not sieved. The pretreatment period was 2 to 14 days.

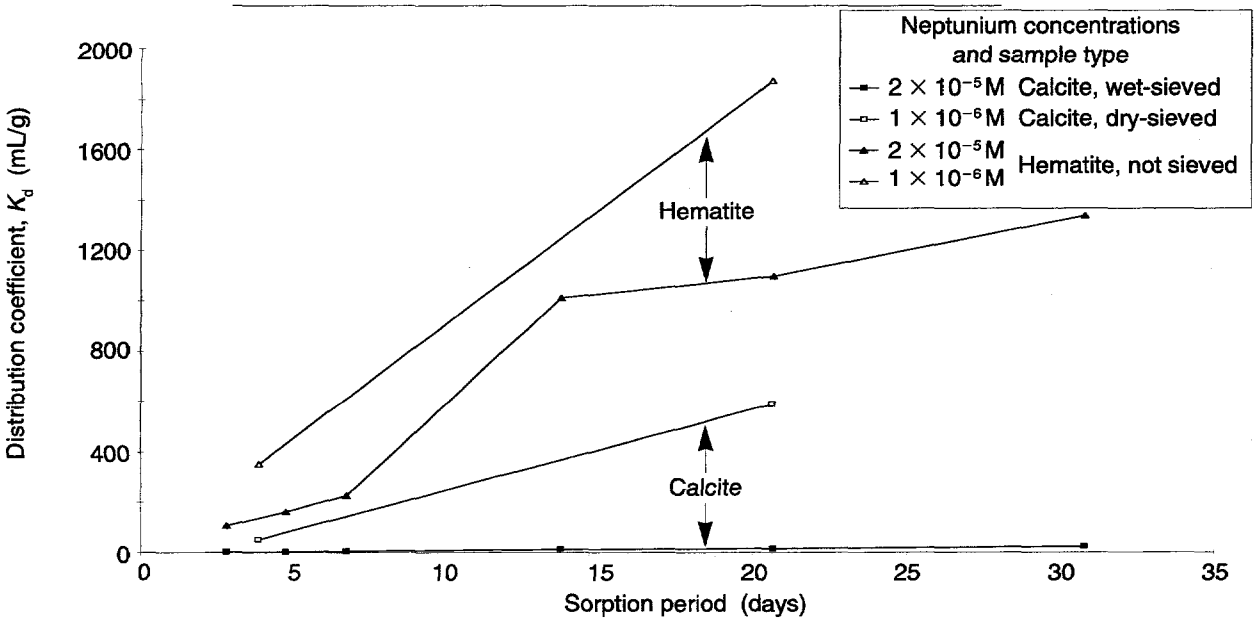

Figure 8. Time Dependence of Neptunium Sorption for Calcite and Hematite in J-13 Water. Variation with time of K_d for sorption of neptunium onto calcite (squares) and hematite (triangles) under atmospheric conditions and at the specified initial neptunium concentrations in J-13 well water. The calcite was either wet- or dry-sieved to particle sizes from 75 to 500 μm; the synthetic hematite was not sieved. The pretreatment period with J-13 water was 2 to 14 days.

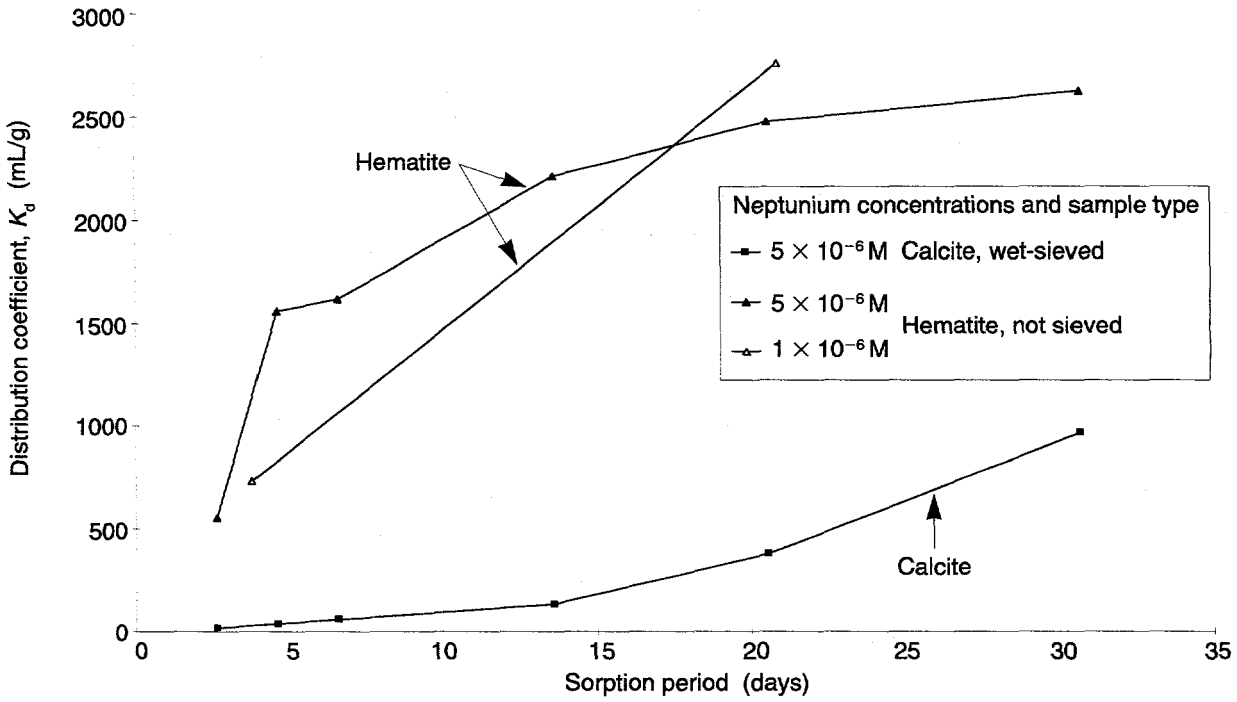

Figure 9. Time Dependence of Sorption for Calcite and Hematite in UE-25 p#1 Water. Variation with time of K_d for the sorption of neptunium onto calcite (squares) and hematite (triangles) under atmospheric conditions and at the specified initial neptunium concentrations in UE-25 p#1 well water. The calcite was wet-sieved to particle sizes ranging from 75 to 500 µm; the synthetic hematite was not sieved. The pretreatment period in UE-25 p#1 water was 2 to 13 days.

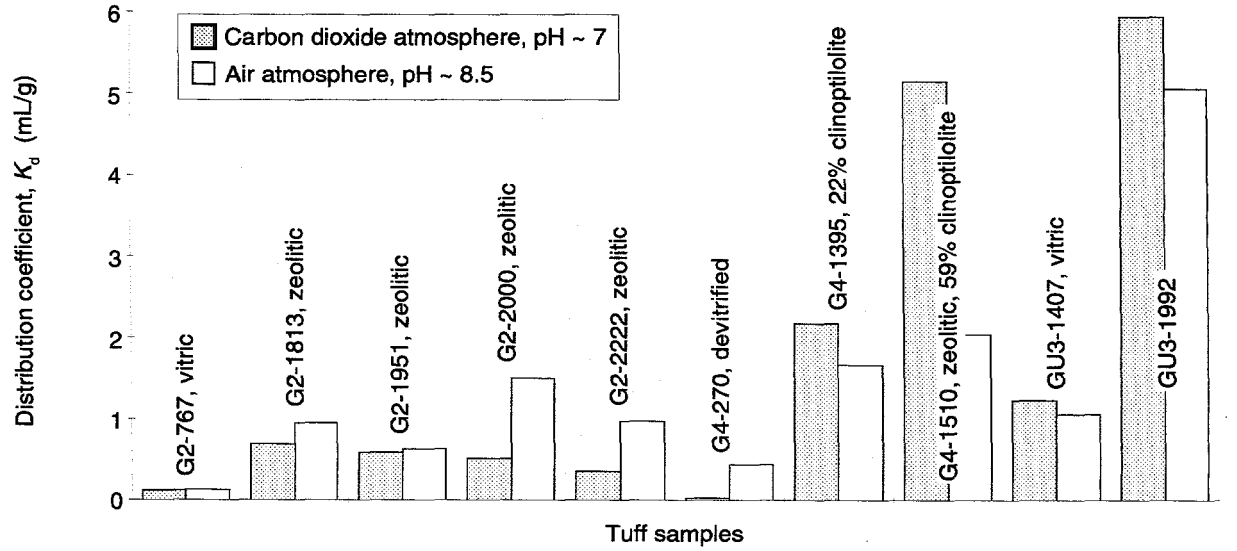

Figure 10. pH Dependence of Sorption at 10^{-7} M. Experimental values of K_d for the sorption of neptunium onto tuffs in J-13 well water at initial concentrations of 6 to 7 × 10^{-7} M are compared for atmospheric conditions (pH ~ 7) and a carbon dioxide overpressure (pH ~8.5). Tuffs were wet-sieved to particle sizes from 75 to 500 µm. The pretreatment period was 2 to 3 days; the sorption period was 3 to 5 days.

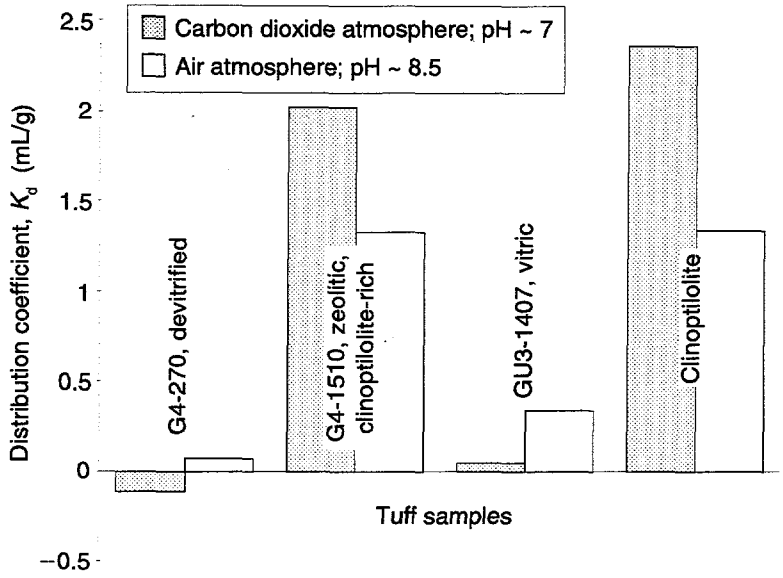

Figure 11. pH Dependence of Sorption at 10^{-5} M. Experimental values of K_d for the sorption of neptunium onto several tuffs and clinoptilolite in J-13 well water at an initial neptunium concentration of 3×10^{-5} M are compared for both atmospheric conditions (pH ~ 8.5) and a carbon dioxide overpressure (pH ~ 7). Tuffs were wet-sieved to particle sizes that ranged from 75 to 500 μm; the clinoptilolite was not sieved. The pretreatment period was 2 to 3 days; the sorption period was 3 to 5 days.

XRD analyses of these samples become available, it is difficult to know the relative amounts of clinoptilolite versus mordenite in each. As shown in Figs. 10 and 11, tuff samples G4-1510 and G4-1395, which consist of 59% and 22% clinoptilolite, respectively, exhibit the same trend as clinoptilolite itself. We observed an increase in sorption for clinoptilolite as the pH is decreased from 8.5 to 7, probably because of the increase of neptunyl cation concentration in J-13 water as the pH decreases. It is tempting to conclude from these results that neptunium sorption onto clinoptilolite follows an ion-exchange mechanism. However, the fact that neptunium sorption on pure clinoptilolite is so small seems to favor a surface complexation reaction (such as ion exchange only at the surface) even for this zeolite. One possible reason for the lack of ion exchange for neptunium in clinoptilolite is the size of the hydrated neptunyl cation, which may not fit in the zeolite cages. The sorption of neptunium onto devitrifed tuffs (such as sample G4-270) in J-13 is not affected by pH.

We also studied the sorption of neptunium in UE-25 p#1 water and found that, regardless of the conditions, neptunium sorption onto tuffs and zeolites is negligible ($K_d < 1$ mL/g) in this water (Fig. 12). If clinoptilolite is the only mineral affecting neptunium sorption and if ion exchange at the surface is the dominating mechanism, one might conclude that the reason for the lack of neptunium sorption on clinoptilolite is the formation of the neptunium carbonato complex ($NpO_2CO_3^-$) in UE-25 p#1 water to the exclusion of the neptunyl cation. As mentioned in the experimental section, the data reported by Nitsche et al. (1994) do not support this conclusion; the relative amount of neptunyl in UE-25 p#1 water is larger than the amount of neptunyl in J-13 water at pH 7. If the data of Nitsche et al. are correct, another possible reason for the lack of neptunium sorption on clinoptilolite in UE-25 p#1 water is competitive effects due to the larger ionic strength of that water compared with J-13 water, which has a smaller ionic strength by nearly an order of magnitude.

As previously reported by Combes et al. (1992), iron oxides have a high affinity for neptunium. Figure 13 shows the sorption of neptunium onto hematite in J-13 and UE-25 p#1 waters as a function of pH. It is important to note that the trends observed in this figure (neptunium sorption increasing with increasing pH and larger neptunium sorption in UE-25 p#1 water than in J-13 water) are not followed by the neptunium sorption reported for clinoptilolite-rich tuff samples. The neptunium sorption in the rest of the tuff samples is so small (even in the samples that contain traces of

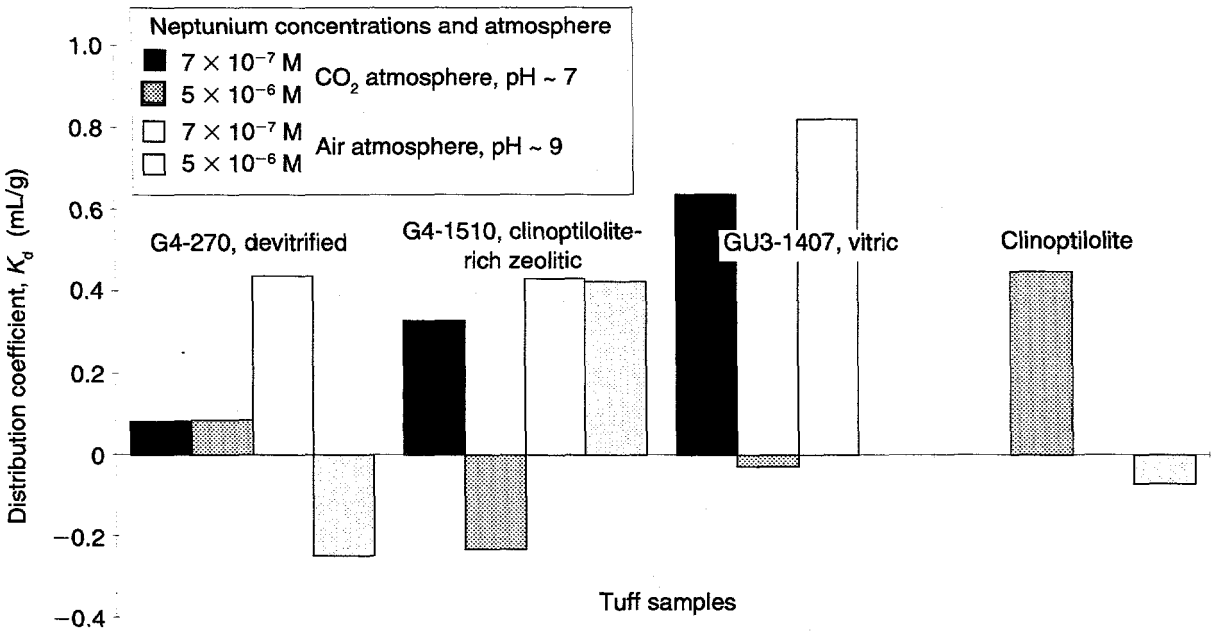

Figure 12. Neptunium Sorption in UE-25 p#1 Well Water. Experimental values of the batch sorption distribution coefficient, K_d, for neptunium in UE-25 p#1 water show negligible sorption regardless of sample type (devitrified tuff, clinoptilolite-rich zeolitic tuff, vitric tuff, or clinoptilolite), pH (~ 7 or ~9), or initial neptunium concentration (5×10^{-6} or 7×10^{-7}). The tuffs were wet-sieved to particle sizes ranging from 75 to 500 μm; the clinoptilolite was not sieved. The pretreatment period was 2 to 3 days, and the sorption period was 3 to 5 days.

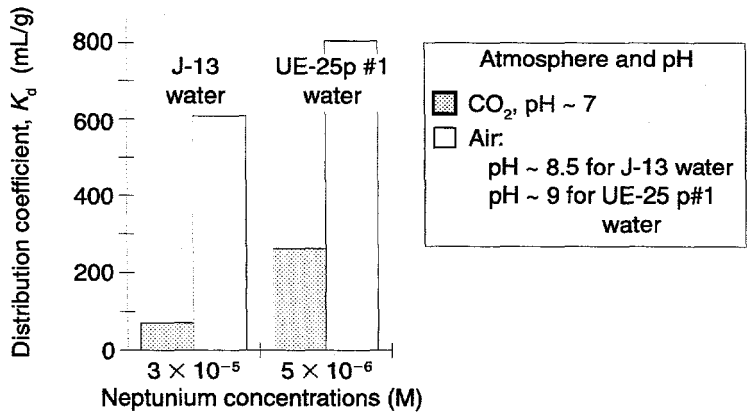

Figure 13. Neptunium Sorption for Hematite. Values of the batch sorption distribution coefficient, K_d, are given for the sorption of neptunium onto hematite in UE-25 p#1 well water at the specified initial neptunium concentrations and pH values. The pretreatment period was 2 to 3 days, and the sorption period was 3 to 5 days.

hematite) that the iron oxides appear to be passivated in the tuffs.

As illustrated in Fig. 14, regardless of the tuff studied, neptunium sorption onto tuffaceous materials is extremely limited except, as noted in Appendix B, for the case of tuff G2-723. However, sample G2-723 contains a large amount of calcite, which is a good sorber for neptunium (Fig. 3). Figure 15 is a plot both of neptunium sorption data in J-13 water and of surface area for tuffs for which BET and XRD analyses exist. The surface area data correspond to the surface area for the tuffs sieved in J-13 water (Appendix C) with the following exceptions: the surface area used for sample G4-2077 was for dry-sieved tuff; the surface area used

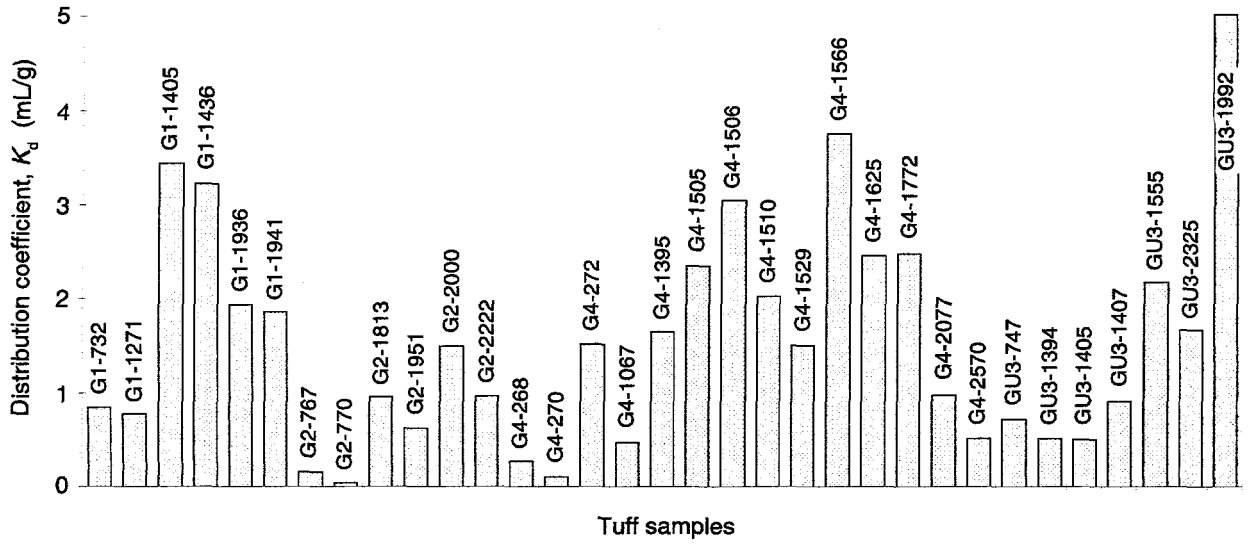

Figure 14. Neptunium Sorption in J-13 Well Water. These values of the batch sorption distribution coefficient, K_d, illustrate the limited sorption of neptunium onto a large range of Yucca Mountain tuffs in J-13 well water under atmospheric conditions. The initial neptunium concentration ranged from 6 to 8×10^{-7} M. The tuffs were wet-sieved to particle sizes that ranged from 75 to 500 µm. The pretreatment period was 2 to 14 days; the sorption period was 3 to 23 days.

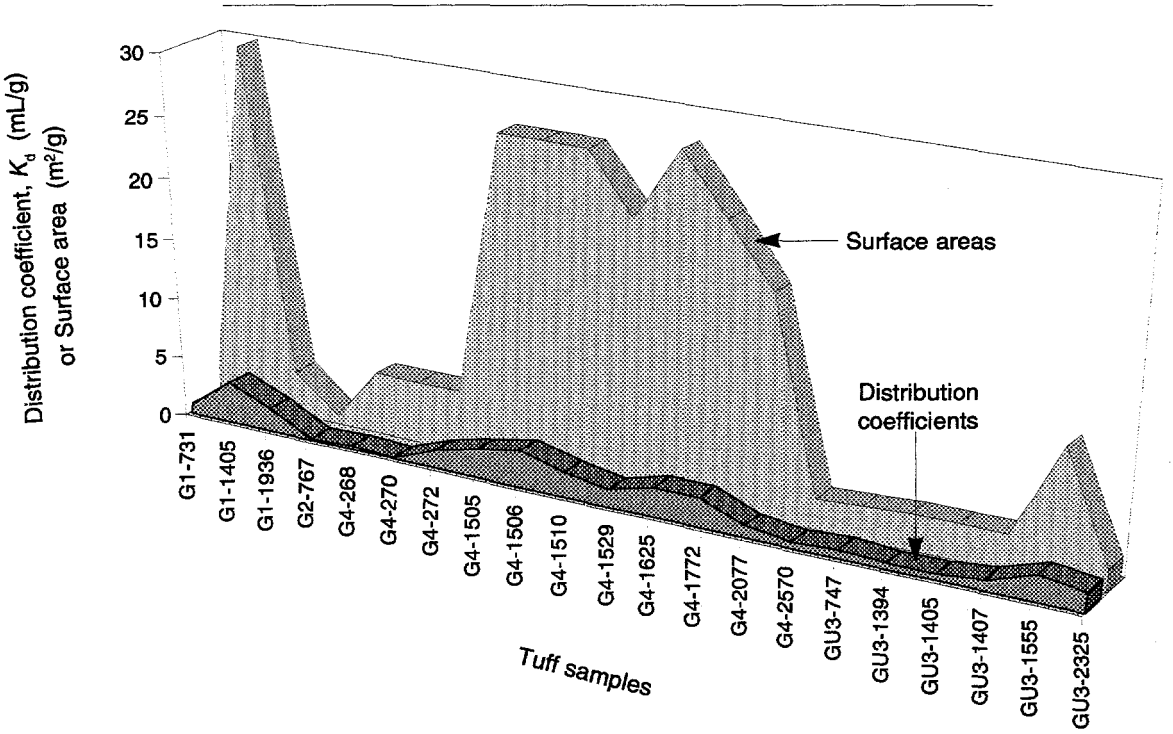

Figure 15. Neptunium Sorption and Surface Area. Values of the batch sorption distribution coefficient, K_d, for neptunium onto various tuffs are compared to the corresponding surface areas of those tuffs. The sorption is for J-13 well water under atmospheric conditions at an initial neptunium concentration ranging from 6 to 8×10^{-7} M. The tuffs were wet-sieved to particle sizes that ranged from 75 to 500 µm. The pretreatment period was 2 to 14 days; the sorption period was 3 to 23 days.

for tuffs G4-268 and G4-272 was the same as that measured for tuff G4-270; the surface area plotted for tuffs G4-1505 and G4-1510 was the same as that measured for tuff G4-1506; and the surface area plotted for tuff GU3-1405 was the same as that measured for tuff GU3-1407. Figure 15 shows a reasonable correlation between sorption and surface area. The surface areas that are larger than 18 m^2/g correspond to clinoptilolite-rich tuffs.

Because sorption is correlated with surface area, we calculated the acid dissociation constant K_a (K_d divided by the surface area of the sorptive material) for clinoptilolite-rich tuff samples and compared these to predicted values based on the value of K_a measured for pure clinoptilolite. The data of Table 4 indicate that reasonable predictions can be made on the basis of neptunium sorption data for pure clinoptilolite (assuming the only sorptive mineral is clinoptilolite).

Figures 16 and 17 summarize the sorption of neptunium under atmospheric conditions for tuffs and minerals as a function of water type. Sorption onto zeolitic tuffs decreases considerably with increasing carbonate content and ionic strength of the water. Figure 17 shows that tuff G2-723 (which consists of 34% calcite) exhibits considerable sorptive capacity for neptunium. Assuming that the calcite in the tuff sample has the same surface area as the natural calcite used for these experiments (and that calcite is the only sorptive mineral in the tuff), one would predict, based on neptunium sorption on pure calcite, the $\log(K_d)$ for tuff G2-723 to be 1.5. This prediction agrees well with the K_d measured for tuff G2-723 (Fig. 17).

As the neptunium concentration is increased towards the solubility limit for neptunium in the J-13 and UE-25 p#1 groundwaters, the observed sorption decreases, but the general trends remain the same (as seen by comparing Figs. 15 and 18). The extremely low neptunium sorption reported for devitrified tuffs in J-13 and UE-25 p#1 waters is supported by the sorption data plotted for albite (Fig. 19), which appears to be a very poor sorber for neptunium (in both waters). The nonlinearity of neptunium sorption in the high-concentration region (approaching the solubility limits for neptunium) is further illustrated in Figs. 20 and 21 (for J-13 and UE-25 p#1 waters at pH 7).

Table 4: Neptunium Sorption in J-13 Water*

Tuff Sample	K_a (m)	Predicted K_a (m)	Percentage of Clinoptilolite
G1-1405	1×10^{-7}	1×10^{-7}	68 ± 7
G4-1505	9×10^{-8}	1×10^{-7}	74 ± 7
G4-1506	1×10^{-7}	1×10^{-7}	62 ± 7
G4-1510	8×10^{-8}	1×10^{-7}	59 ± 7
G4-1529	7×10^{-8}	1×10^{-7}	59 ± 8
G4-1625	9×10^{-8}	1×10^{-7}	61 ± 7
G4-1772	1×10^{-7}	1×10^{-7}	63 ± 5
G4-2077	5×10^{-8}	8×10^{-8}	51 ± 8

*Atmospheric conditions; initial neptunium concentrations ranged from 6 to 8 $\times 10^{-7}$ M; tuffs were wet-sieved to particle sizes ranging from 75 to 500 μm; the pretreatment period was 2 to 14 days; and the sorption period was 3 to 23 days.

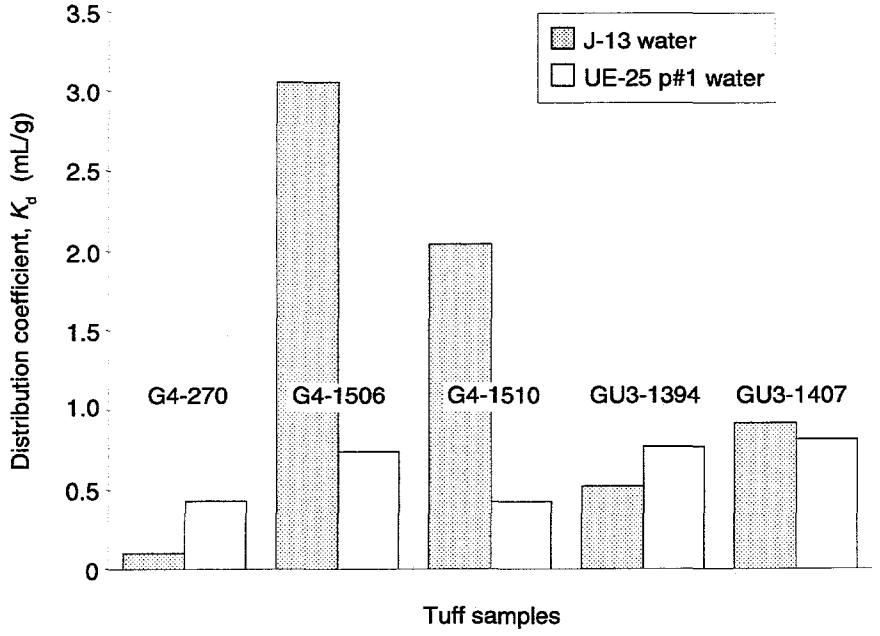

Figure 16. Dependence on Water for Sorption onto Tuffs. Values of K_d for sorption of neptunium onto several tuffs that allow comparison of sorption (under atmospheric conditions) for the two types of groundwaters. The initial neptunium concentration ranged from 6 to 8×10^{-7} M. The tuffs were wet-sieved to particle sizes ranging from 75 to 500 µm. The pretreatment period was 2 to 14 days, and the sorption period was 3 to 23 days.

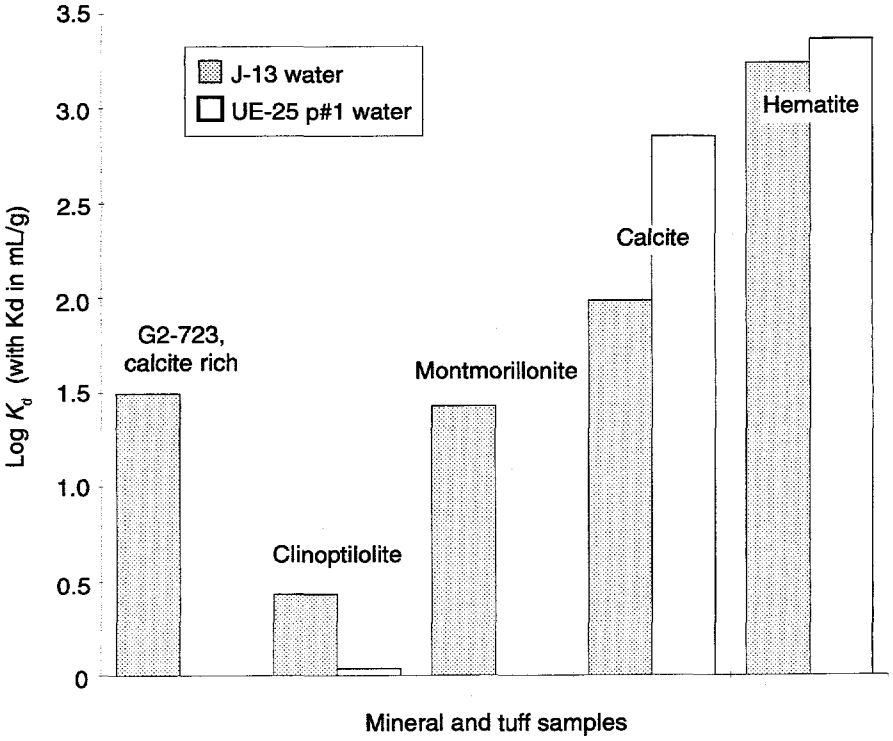

Figure 17. Dependence on Water for Sorption onto Minerals. Values of K_d for neptunium onto several minerals and a calcite-rich tuff that allow comparison of sorption (under atmospheric conditions) for the two groundwaters. The initial neptunium concentration ranged from 6 to 8×10^{-7} M. The tuff and the calcite were wet-sieved to particle sizes ranging from 75 to 500 µm, the montmorillonite was dry-sieved, and the clinoptilolite and hematite were not sieved. The sorption period was 17 to 22 days.

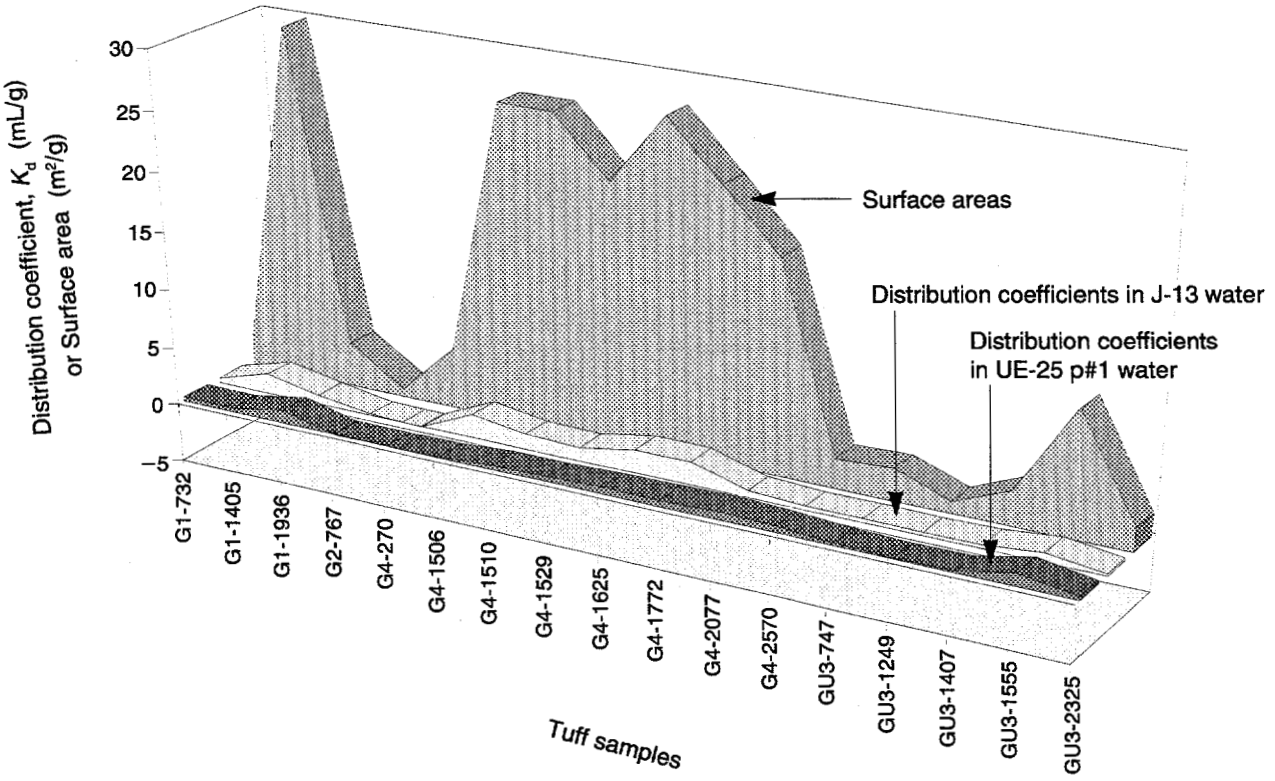

Figure 18. High-Concentration Sorption onto Tuffs. Values of K_d for sorption of neptunium onto tuffs under atmospheric conditions and near the solubility limit (initial neptunium concentrations of 2 to 4×10^{-5} M in J-13 water and 5×10^{-6} M in UE-25 p#1 water) are compared with the surface areas of those tuffs. The tuffs were wet-sieved to particle sizes ranging from 75 to 500 μm. The pretreatment period was 2 to 5 days; the sorption period was 2 to 4 days.

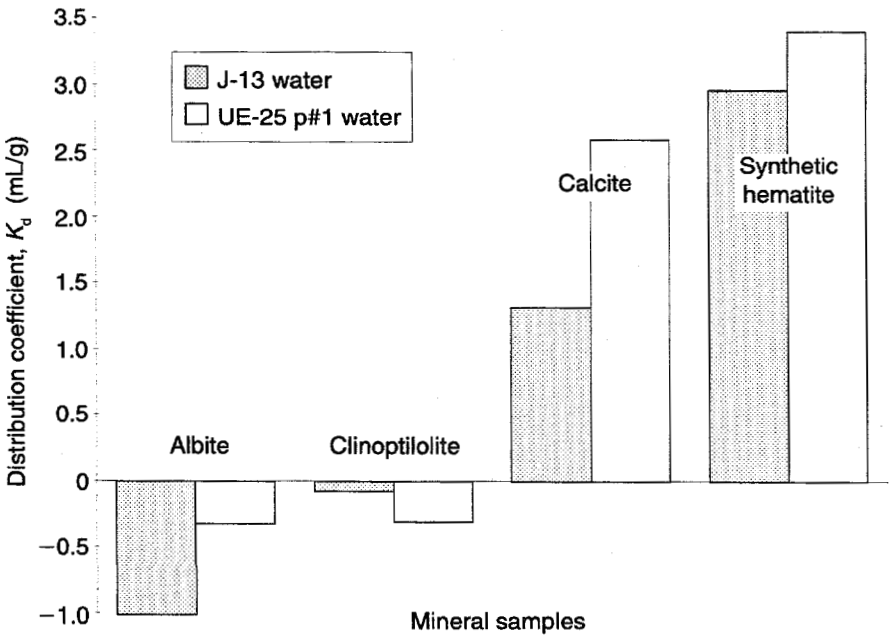

Figure 19. High-Concentration Sorption onto Minerals. Values of K_d for sorption of neptunium onto minerals under atmospheric conditions for neptunium concentrations near the solubility limit (initially, 2 to 4×10^{-5} M in J-13 water and 5×10^{-6} M in UE-25 p#1 water). The calcite was wet-sieved to particle sizes ranging from 75 to 500 μm; the others were not sieved. The pretreatment period was 2 to 31 days; the sorption period was 21 days.

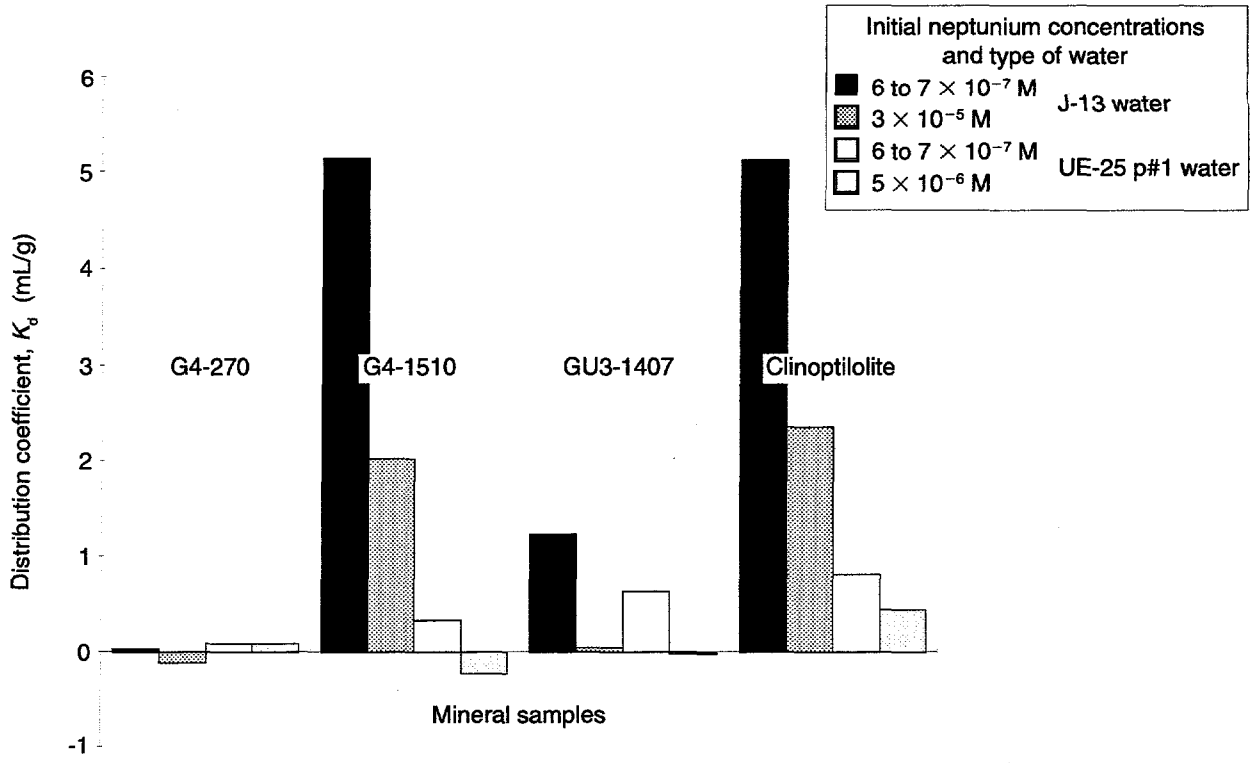

Figure 20. High-Concentration Sorption onto Tuffs at pH 7. Values of K_d for sorption of neptunium onto several tuffs and clinoptilolite under a carbon-dioxide overpressure (to obtain a pH of approximately 7) are shown. The tuffs were wet-sieved to particle sizes ranging from 75 to 500 μm; the clinoptilolite was not sieved. The pretreatment period was 2 to 3 days; the sorption period was 3 to 4 days.

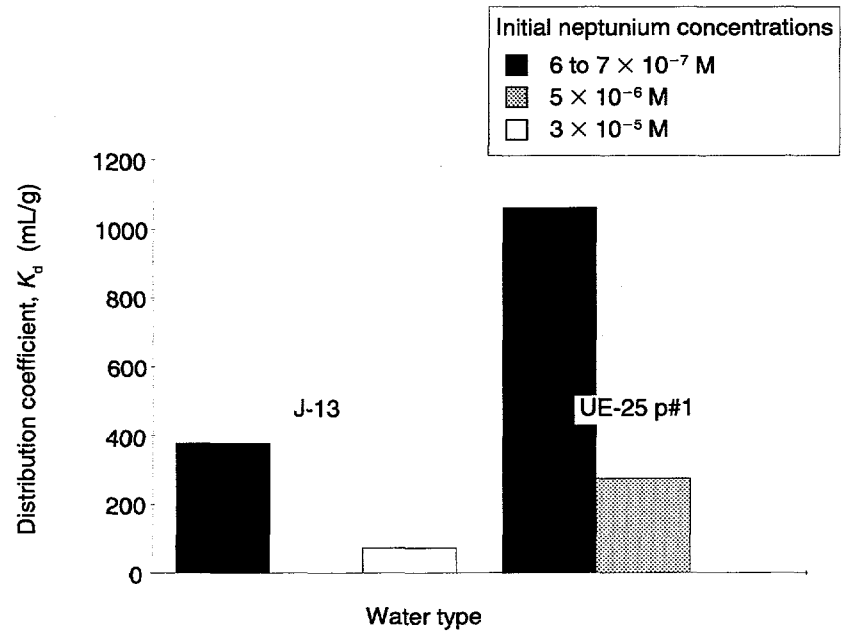

Figure 21. High-Concentration Sorption onto Hematite at pH 7. Values of K_d are shown for sorption of neptunium onto unsieved synthetic hematite under a carbon dioxide overpressure (to obtain a pH of ~7). The pretreatment period was 2 to 3 days; the sorption period was 3 to 4 days.

SUMMARY

Studies were conducted to elucidate the sorption of neptunium (in the Np(V) oxidation state under oxidizing conditions) onto four major types of Yucca Mountain tuffs in two types of sodium bicarbonate groundwaters from Yucca Mountain. The four types of tuff were devitrified, vitric, zeolitic (with emphasis on clinoptilolite-rich samples), and calcite-rich. Pure mineral separates were used to identify the major sorbing minerals in the tuff experiments. Findings are as follows:

- Significant neptunium sorption onto calcite and calcite-rich tuffs occurs, which is important because if fast flow paths are correlated with fractures coated with calcite, a significant amount of neptunium retardation can be expected under fractured-flow scenarios.

- Moderate batch sorption coefficients (in the range from 2 to 5 mL/g) occur for clinoptilolite-rich zeolitic tuffs in J-13 well water in the pH range from 7 to 8.5.

- Neptunium sorption increases with decreasing pH in clinoptilolite-rich zeolitic tuffs in J-13 well water.

- Neptunium sorption onto clinoptilolite-rich zeolitic tuffs correlates to surface area and amount of clinoptilolite, and reasonable predictions can be made based on neptunium sorption data for pure clinoptilolite (assuming that clinoptilolite is the only sorptive mineral in the zeolitic tuffs).

- Negligible neptunium sorption occurs for zeolitic tuffs in UE-25 p#1 groundwater in the pH range from 7 to 9.

- Negligible neptunium sorption occurs for devitrified and vitric tuffs in both J-13 and UE-25 p#1 groundwaters in the pH range from 7 to 9.

- Iron oxides appear to be passivated in tuffs so that they do not contribute to the observed sorption even though neptunium sorption onto synthetic iron oxide is significant.

RECOMMENDATIONS FOR FURTHER RESEARCH

The reported findings lead to the conclusion that future efforts should be devoted to acquiring data for neptunium sorption onto calcite and clinoptilolite as a function of neptunium concentration, pH, carbonate content of the water, and ionic strength. These efforts should yield a fundamental understanding of the sorption reactions controlling neptunium sorption onto calcite and clinoptilolite. Development of this framework will allow the generation of defensible neptunium sorption probability distributions as a function of mineralogy and groundwater chemistry at Yucca Mountain. These distributions can be used in performance assessment calculations to predict neptunium retardation in tuffs as a result of sorption.

ACKNOWLEDGMENTS

The authors wish to thank Dr. John Husler (from the University of New Mexico) for the chemical analysis of the groundwaters used in the sorption experiments, Phil Palmer (from the Materials and Chemical Design Group at LANL) for providing the Np(V) acidic stock used to prepare the neptunium solutions, and Quantachrome Corporation for the BET analyses of the tuffs and minerals.

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Note on Sample IDs in Appendix B

For readability and ease of presentation, the data presented in tables in Appendix B have been consolidated from quality-program-approved and audited electronic notebooks by having repetitive information, including sample IDs, summarized in the subheadings for each series of samples. As a result, there are some minor differences in the sample IDs listed in the tables and those present in the electronic notebooks. These differences are noted below and are recorded in the original binder containing the data (TWS-INC-03-93-01).

Appendix B Sample ID	Data Binder Sample ID
J-13 G1-732-C.541-20	J-13 G1-732-C541-20
J-13-G4 270-C.437-20	J-13 G4-270-C.437-20
J-13-G4 270-C.438-20	J-13 G4-270-C.438-20
J-13-G4 270-C.569-20	J-13 G4-270-C.569-20
J-13-G4 270-C.570-20	J-13 G4-270-C.570-20
J-13 G4-270-C.627	J-13 G4-270-C.627-20
J-13-G-4 270-C.341-20	J-13-G4 270-C.341-20
J-13-G-4 270-C.342-20	J-13-G4 270-C.342-20
J-13 G4-1506-C.73-20	J-13-G-4 1506-C.73-20
J-13 G4-1506-C.74-20	J-13-G-4 1506-C.74-20
J-13 G4-1506-C.229-20	J-13-G-4 1506-C.229-20
J-13 G4-1506-C.230-20	J-13-G-4 1506-C.230-20
J-13 G4-1506-C.397-20	J-13-G4 1506-C.397-20
J-13 G4-1506-C.398-20	J-13-G4 1506-C.398-20
J-13-G-4 1506-C.343-20	J-13-G4 1506-C.343-20
J-13-G-4 1506-C.344-20	J-13-G4 1506-C.344-20
J-13-GU3-1394-C.318-20-LC	J-13-GU3 1394-C.318-20-LC
J-13 GU3-1394-C.399-20	J-13-GU3 1394-C.399-20
J-13 GU3-1394-C.400-20	J-13-GU3 1394-C.400-20
J-13-A-C.573-20	J-13 A-C.573-20
J-13-A-C.574-20	J-13 A-C.574-20
J-13-B-C.575-20	J-13 B-C.575-20
J-13-B-C.576-20	J-13 B-C.576-20
J-13-C-C.577-20	J-13 C-C.577-20
J-13-C-C.578-20	J-13 C-C.578-20
J-13-G-C.581-20	J-13 G-C.581-20
J-13-G-C.582-20	J-13 G-C.582-20
J-13-M-C.579-20	J-13 M-C.579-20
J-13-M-C.580-20	J-13 M-C.580-20
P-1 G4-270-C.301-20	P-1-G-4 270-C.301-20
P-1 G4-270-C.377-20	P-1-G4 270-C.377-20
P-1 G4-270-C.378-20	P-1-G4 270-C.378-20
P-1-G-4 1506-C.615-20	P-1 G4-1506-C.615-20
P-1-G-4 1506-C.616-20	P-1 G4-1506-C.616-20
P-1-G-4 1506-C.379-20	P-1-G4 1506-C.379-20
P-1-G-4 1506-C.380-20	P-1-G4 1506-C.380-20
P-1-G-4 1506-C.361-20	P-1-G4 1506-C.361-20
P-1-G-4 1506-C.362-20	P-1-G4 1506-C.362-20
P-1 G4-1625-C.605-20	P-1 G4-1625-C605-20
P-1-A-C.617-20	P-1 A-C.617-20
P-1-A-C.618-20	P-1 A-C.618-20
P-1-B-C.619-20	P-1 B-C.619-20
P-1-B-C.620-20	P-1 B-C.620-20
P-1-C-C.621-20	P-1 C-C.621-20
P-1-C-C.622-20	P-1 C-C.622-20
P-1-G-C.625-20	P-1 G-C.625-20
P-1-G-C.626-20	P-1 G-C.626-20
P-1-M-C.623-20	P-1 M-C.623-20
P-1-M-C.624-20	P-1 M-C.624-20

APPENDIX A

CHEMICAL ANALYSIS OF WATERS FROM WELLS J-13 AND UE-25 p#1

APPENDIX A: CHEMICAL ANALYSIS OF WATERS FROM WELLS J-13 AND UE-25 P#1

Concentrations (mg/L)	J-13 Collected 1963 to 1987	J-13 SPC00007994 Unfiltered	J-13 SPC00007994 Filtered	J-13 SPC00007995 Unfiltered	J-13 SPC00007995 Filtered	J-13 SPC00007996 Unfiltered	J-13 SPC00007996 Filtered
Silicon	29	20	20	23	23	30	30
Aluminum		< 0.1	< 0.1	< 0.3	< 0.3	< 0.15	< 0.15
Iron		< 0.01	< 0.01	< 0.1	< 0.1	< 0.4	< 0.4
Manganese		< 0.01	< 0.01	< 0.1	< 0.1	< 0.01	< 0.01
Magnesium	2.0	1.7	1.6	1.7	1.6	1.9	2.0
Calcium	13.0	12.8	13.3	12.7	12.3	12.7	12.7
Sodium	46	46	47	46	47	44	47
Potassium	5.0	5.2	5.4	4.4	4.4	4.6	4.7
Cesium		< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Lithium	0.05	0.04	0.04	< 0.04	0.04	0.46	0.05
Carbonate		2.5	1.5		1.6	< 0.1	< 0.1
Bicarbonate	129	118	119	129	121	126	127
Fluoride	2.2	2.3	2.2	2.2	2.3	2.3	2.4
Chloride	7.1	6.9	7.2	5.7	7.7	7.4	7.6
Sulfate	18.4	23.0	27.0	15.0	17.0	20.6	21.4
Nitrate	8.9	9.0	8.6	15.0	7.5	1.5	1.7
TOC		0.44	0.58		0.47	1.62	1.10
pH	6.9	8.5	8.4		8.5	8.0	7.8
Date Collected	1963 to 1987	4/27/92	4/27/92	4/27/92	4/27/92	4/27/92	4/27/92
Date Filtered	N/A	N/A	5/8/92	N/A	5/8/92	N/A	2/24/93
Filter Size (µm)	N/A	N/A	0.03	N/A	0.03	N/A	0.05
Results found in:	UCID-21867, pages 4.2 and 4.3	TWS-INC11-9/82-49, page 40	TWS-INC11-9/82-49, page 40	TWS-INC11-9/82-49, pages 34, 35	TWS-INC11-9/82-49, pages 34, 35	TWS-INC-03-93-02, page C8	TWS-INC-03-93-02, page C8J-13

APPENDIX A: CHEMICAL ANALYSIS OF WATERS FROM WELLS J-13 AND UE-25 P#1

Concentrations (mg/L)	J-13 SPC00100297 Unfiltered	J-13 SPC00100297 Filtered	UE-25 p#1 Unfiltered (Analyzed at Site)	UE-25 p#1 Unfiltered	UE-25 p#1 Filtered	UE-25 p#1 Filtered	UE-25 p#1 Filtered	UE-25 p#1 Filtered
Silicon	30	30	30	17	14	19	20	21
Aluminum	< 0.15	< 0.15	0.1	< 0.3	< 0.3	< 0.3	< 0.15	< 0.15
Iron	< 0.4	< 0.4	< 0.1	< 0.1	< 0.05	< 0.1	1.0	0.5
Manganese	< 0.01	< 0.01	< 0.1	< 0.1	< 0.01	< 0.1	0.08	< 0.01
Magnesium	1.9	1.9	32	35	32	34	36	35
Calcium	12.6	12.6	88.0	7.0	8.0	7.2	7.4	7.5
Sodium	46	44	171	184	148	151	147	147
Potassium	4.6	4.6	13.4	10.7	11.2	10.3	11.9	11.9
Cesium	< 0.2	< 0.2		< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Lithium	0.04	0.04	0.32	0.41	0.50	0.40	0.54	0.54
Carbonate	< 0.1	< 0.1		28.7	30.5	23.2	17.3	15.3
Bicarbonate	120	122	698	299	303	302	320	324
Fluoride	2.3	2.3	3.5	4.0	4.0	4.0	4.3	4.1
Chloride	7.4	7.3	37	24	25	25	24	25
Sulfate	20.4	20.5	129	170	162	178	168	156
Nitrate	1.4	1.5	< 0.1	0.1	0.5	0.1	< 0.1	< 0.1
TOC	1.67	0.85		0.96	1.89		2.51	1.43
pH	7.9	7.8	6.7	9.0	9.0	9.0	8.7	8.6
Date Collected	7/8/93	7/8/93	N/A	N/A	N/A	N/A	N/A	N/A
Date Filtered	N/A	8/4/93	N/A	N/A	7/20/83	7/20/83	7/20/83	2/24/93
Filter Size (µm)	N/A	0.05	N/A	N/A	0.05	0.05	0.05	0.05
Results found in:	TWS-INC-03-93-02, page C8	TWS-INC-03-93-02, page C8	LA-10188-MS pages 9,10	TWS-INC11-9/82-49, pages 34, 35	TWS-INC11-9/82-49, page 25	TWS-INC11-9/82-49, pages 34, 35	TWS-INC-03-93-02, page C8	TWS-INC-03-93-02, page C8

APPENDIX B

NEPTUNIUM BATCH SORPTION EXPERIMENTAL DATA AND RESULTS

APPENDIX B: NEPTUNIUM BATCH SORPTION EXPERIMENTAL DATA AND RESULTS

XXXX part of sample ID	Np sorp/ desorp Expt. #	Mass of mineral (g)	Groundwater Pretreatment				Neptunium-237 Solution Sorption Treatment									Distr. Coeff., K_d (mL/g)
			Mass of added water (g)	Period (days)	Final pH	Final Eh	Mass of added soln (g)	Period (days)	Soln/solid ratio (mL/g of solid) Initial	Soln/solid ratio (mL/g of solid) Final	Final pH	Final Eh	Alpha activity in soln (cpm/g of soln) Initial	Alpha activity in soln (cpm/g of soln) Final	Alpha activity in soln (cpm/g of soln) Control	
Tuff USW G1-732																
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: J-13 G1-732-C.XXXX-20																
481	11	1.00	19.95	2	8.5	120	20.04	2	20.90	20.84	8.5	173	11304.8	10564.8	11075.1	0.6
482	11	1.00	19.91	2	N/A	N/A	19.91	2	20.60	20.56	N/A	N/A	11304.8	10739.8	11075.1	0.4
541	12	1.02	19.84	2	8.6	196	19.80	3	20.15	20.14	8.2	181	11256.1	10710.5	11333.6	0.3
542	12	1.04	19.82	2	N/A	N/A	19.83	3	19.75	19.74	N/A	N/A	11256.1	10636.0	11333.6	0.4
Same as previous heading except: Data binder: TWS-INC-10-93-06																
2006	20	1.01	20.03	2	8.3	204	19.97	3	20.46	20.45	8.4	204	291.0	269.6	290.2	0.9
2007	20	1.01	19.95	2	N/A	N/A	19.89	3	20.38	20.38	N/A	N/A	291.0	270.6	290.2	0.8
Air atmosphere, UE-25 p#1 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: P-1 G1-732-C.XXXX-20																
511	11	1.00	19.92	3	8.9	129	20.14	2	20.94	20.93	8.9	159	1851.1	1723.1	1823.5	0.7
512	11	1.00	19.88	3	N/A	N/A	20.09	2	20.82	20.81	N/A	N/A	1851.1	1727.9	1823.5	0.7
585	12	1.01	19.98	3	8.8	181	20.04	3	20.50	20.46	9.0	179	1748.7	1692.8	1752.0	0.04
586	12	1.03	19.99	3	N/A	N/A	20.02	3	20.25	20.22	N/A	N/A	1748.7	1677.7	1752.0	0.04
Tuff USW G1-1271																
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: G1-1271																
none	14	1.00	19.86	6	8.4	199	20.26	23	20.84	20.32	8.5	178	250.5	235.7	255.7	1
none	14	1.01	19.86	6	N/A	N/A	20.03	23	20.39	20.28	N/A	N/A	250.5	240.8	255.7	0.4

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XXXX part of sample ID	Np sorp/ desorp Expt. #	Mass of mineral (g)	Groundwater Pretreatment				Neptunium-237 Solution Sorption Treatment									Distr. Coeff., K_d (mL/g)
			Mass of added water (g)	Period (days)	Final pH	Final Eh	Mass of added soln (g)	Period (days)	Soln/solid ratio (mL/g of solid)		Final pH	Final Eh	Alpha activity in soln (cpm/g of soln)			
									Initial	Final			Initial	Final	Control	
Tuff USW G1-1405																
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: J-13 G1-1405-C.XXXX-20																
483	11	1.00	19.87	2	8.6	125	19.99	2	20.94	20.88	8.5	167	11304.8	10060.3	11075.1	2
484	11	1.00	19.93	2	N/A	N/A	20.01	2	20.98	20.93	N/A	N/A	11304.8	9982.0	11075.1	2
543	12	1.02	20.28	2	8.6	197	19.79	3	20.26	20.25	8.3	179	11256.1	9933.1	11333.6	2
544	12	1.00	19.96	2	N/A	N/A	19.86	3	20.66	20.65	N/A	N/A	11256.1	9916.7	11333.6	2
Same as previous heading except: Data binder: TWS-INC-10-93-06																
2008	20	1.00	19.95	2	8.3	208	19.90	3	20.68	20.68	8.4	209	291.0	240.1	290.2	3
2009	20	1.00	19.96	2	N/A	N/A	19.96	3	20.75	20.75	N/A	N/A	291.0	239.9	290.2	3
Air atmosphere, UE-25 p#1 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: P-1 G1-1405-C.XXXX-20																
513	11	1.00	19.78	3	8.9	128	20.11	2	21.01	20.99	8.9	156	1851.1	1726.6	1823.5	0.6
514	11	1.00	19.94	3	N/A	N/A	20.09	2	21.04	21.04	N/A	N/A	1851.1	1723.6	1823.5	0.5
587	12	1.00	20.03	3	9.0	192	20.06	3	20.87	20.89	8.9	161	1748.7	1677.2	1752.0	0.03
588	12	1.02	20.00	3	N/A	N/A	20.03	3	20.40	20.41	N/A	N/A	1748.7	1675.4	1752.0	0.09
Tuff USW G1-1436																
CO_2 atmosphere, J-13 groundwater, Wet-sieved (75-500 μm), Temperature range: 18–20°C, Data binder: LA-CST-03-94-09 Sample IDs: J-13-G1 1436-C.XXXX-25																
2303	46	1.02	19.68	2	N/A	N/A	19.41	4	20.28	20.23	7.0	N/A	238.1	178.4	239.2	5
2304	46	0.98	18.42	2	N/A	N/A	19.57	4	21.16	21.10	N/A	N/A	238.1	187.4	239.2	4
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: LA-CST-03-94-09 Sample IDs: J-13 G1-1436-C.XXXX-25																
2357	47	1.01	19.90	2	N/A	N/A	19.89	5	20.46	20.44	N/A	N/A	266.0	220.3	266.9	3
2357	47	1.00	19.88	2	8.4	N/A	19.91	5	20.72	20.69	8.2	N/A	266.0	222.5	266.9	3

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XXXX part of sample ID	Np sorp/ desorp Expt. #	Mass of mineral (g)	Groundwater Pretreatment				Neptunium-237 Solution Sorption Treatment									Distr. Coeff., K_d (mL/g)
			Mass of added water (g)	Period (days)	Final pH	Final Eh	Mass of added soln (g)	Period (days)	Soln/solid ratio (mL/g of solid) Initial	Soln/solid ratio (mL/g of solid) Final	Final pH	Final Eh	Alpha activity in soln (cpm/g of soln) Initial	Alpha activity in soln (cpm/g of soln) Final	Alpha activity in soln (cpm/g of soln) Control	
Tuff USW G1-1936																
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: J-13 G1-1936-C.XXXX-20																
485	11	1.00	19.91	2	8.5	136	19.98	2	20.76	20.70	8.5	185	11304.8	10467.2	11075.1	0.9
486	11	1.00	19.93	2	N/A	N/A	19.96	2	20.76	20.72	N/A	N/A	11304.8	10436.3	11075.1	0.9
545	12	1.10	19.92	2	8.5	204	20.05	3	19.06	19.05	8.3	200	11256.1	10370.2	11333.6	0.7
546	12	0.99	19.74	2	N/A	N/A	20.24	3	21.28	21.28	N/A	N/A	11256.1	10510.2	11333.6	0.6
Same as previous heading except: Data binder: TWS-INC-10-93-06																
2010	20	1.00	19.99	2	8.4	204	19.93	3	20.68	20.68	8.3	213	291.0	259.1	290.2	2
2011	20	1.01	19.98	2	N/A	N/A	19.92	3	20.50	20.49	N/A	N/A	291.0	253.2	290.2	2
Air atmosphere, UE-25 p#1 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: P-1 G1-1936-C.XXXX-20																
515	11	1.00	19.87	3	8.9	135	20.10	2	20.90	20.89	8.9	157	1851.1	1677.1	1823.5	1
516	11	1.00	19.93	3	N/A	N/A	20.08	2	20.86	20.86	N/A	N/A	1851.1	1669.8	1823.5	1
589	12	1.05	19.99	3	8.8	166	20.05	3	19.83	19.84	8.9	164	1748.7	1606.6	1752.0	0.9
590	12	1.01	20.00	3	N/A	N/A	20.04	3	20.74	20.76	N/A	N/A	1748.7	1614.0	1752.0	0.7
Tuff USW G1-1941																
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: G1-1941																
none	14	1.01	19.90	6	8.3	162	20.16	23	20.70	20.46	8.4	170	250.5	224.6	255.7	2
none	14	1.03	19.86	6	N/A	N/A	20.23	23	20.51	20.17	N/A	N/A	250.5	222.5	255.7	2

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XXXX part of sample ID	Np sorp/ desorp Expt. #	Mass of mineral (g)	Groundwater Pretreatment				Neptunium-237 Solution Sorption Treatment									Distr. Coeff., K_d (mL/g)
			Mass of added water (g)	Period (days)	Final pH	Final Eh	Mass of added soln (g)	Period (days)	Soln/solid ratio (mL/g of solid)		Final pH	Final Eh	Alpha activity in soln (cpm/g of soln)			
									Initial	Final			Initial	Final	Control	
Tuff USW G2-723, Calcite-rich																
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 µm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: G2-723																
none	14	1.01	19.92	6	8.3	182	20.06	23	20.60	20.42	8.5	178	250.5	96.6	255.7	30
none	14	1.00	19.98	6	N/A	N/A	20.12	23	20.84	20.54	N/A	N/A	250.5	95.7	255.7	30
Tuff USW G2-767, Vitric																
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 µm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: J-13 G2-767-C.XXXX-20																
497	11	1.00	19.96	2	8.5	153	20.13	2	20.77	20.67	8.5	207	11304.8	11130.0	11075.1	−0.2
498	11	1.00	19.87	2	N/A	N/A	19.98	2	20.55	20.47	N/A	N/A	11304.8	10995.1	11075.1	0.07
557	12	1.13	20.18	2	9.1	171	19.93	3	18.38	18.37	8.3	197	11256.1	10744.0	11333.6	0.1
558	12	1.02	19.98	2	N/A	N/A	19.96	3	20.24	20.23	N/A	N/A	11256.1	10713.2	11333.6	0.3
Same as previous heading except: Data binder: TWS-INC-10-93-06																
2020	20	1.00	19.99	3	8.3	210	19.95	3	20.46	20.45	8.4	193	291.0	281.3	290.2	0.2
2021	20	1.02	19.94	3	N/A	N/A	20.05	3	20.16	20.15	N/A	N/A	291.0	282.4	290.2	0.1
Same as previous complete heading except: Data binder: LA-CST-03-94-09 and Sample IDs: J-13 G2-767 C.XXXX-25																
2359	47	1.00	19.87	2	N/A	N/A	19.90	5	20.43	20.39	N/A	N/A	266.0	256.8	266.9	0.2
2359	47	1.01	19.88	2	8.5	N/A	19.89	5	20.21	20.17	8.2	N/A	266.0	259.1	266.9	0.05
Air atmosphere, UE-25 p#1 groundwater, Wet-sieved (75-500 µm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: P-1 G2-767-C.XXXX-20																
527	12	1.00	19.86	3	8.9	130	20.08	2	20.74	20.73	8.9	146	1851.1	1757.3	1823.5	0.4
528	12	1.00	19.91	3	N/A	N/A	20.10	2	20.85	20.84	N/A	N/A	1851.1	1747.9	1823.5	0.5
601	12	1.00	19.83	3	8.9	167	20.04	3	20.78	20.84	8.9	158	1748.7	1728.3	1752.0	−0.6
602	12	1.01	19.86	3	N/A	N/A	20.04	3	20.42	20.42	N/A	N/A	1748.7	1736.1	1752.0	−0.4
CO_2 atmosphere, J-13 groundwater, Wet-sieved (75-500 µm), Temperature range: 18–20°C, Data binder: LA-CST-03-94-09 Sample IDs: J-13-G2 767-C.XXXX-25																
2305	46	0.96	19.49	2	N/A	N/A	19.64	4	21.45	21.38	7.0	N/A	238.1	225.9	239.2	0.2
2306	46	1.02	18.97	2	N/A	N/A	19.69	4	20.20	20.13	N/A	N/A	238.1	227.7	239.2	0.06

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XXXX part of sample ID	Np sorp/ desorp Expt. #	Mass of mineral (g)	Groundwater Pretreatment				Neptunium-237 Solution Sorption Treatment									Distr. Coeff., K_d (mL/g)
			Mass of added water (g)	Period (days)	Final pH	Final Eh	Mass of added soln (g)	Period (days)	Soln/solid ratio (mL/g of solid) Initial	Soln/solid ratio (mL/g of solid) Final	Final pH	Final Eh	Alpha activity in soln (cpm/g of soln) Initial	Alpha activity in soln (cpm/g of soln) Final	Alpha activity in soln (cpm/g of soln) Control	
Tuff USW G2-770																
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: G2-770																
none	14	1.01	19.97	6	8.4	196	20.20	23	20.63	20.27	8.4	182	250.5	245.0	255.7	0.2
none	14	1.01	20.00	6	N/A	N/A	20.18	23	20.53	20.33	N/A	N/A	250.5	247.4	255.7	−0.1
Tuff USW G2-1813, Zeolitic																
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: G2-1813																
none	14	1.00	19.98	6	8.2	197	20.19	23	21.15	20.99	8.4	184	250.5	230.4	255.7	1
none	14	1.01	19.96	6	N/A	N/A	20.12	23	20.99	20.76	N/A	N/A	250.5	229.9	255.7	1
Same as previous heading except: Data binder: LA-CST-03-94-09 and Sample IDs: J-13 G2-1813 C.XXXX-25																
2361	47	1.00	19.91	2	N/A	N/A	19.88	5	20.76	20.72	N/A	N/A	266.0	242.2	266.9	1
2361	47	1.01	19.91	2	8.0	N/A	19.88	5	20.50	20.49	8.1	N/A	266.0	245.8	266.9	0.8
CO_2 atmosphere, J-13 groundwater, Wet-sieved (75-500 μm), Temperature range: 18–20°C, Data binder: LA-CST-03-94-09 Sample IDs: J-13-G2 1813-C.XXXX-25																
2307	46	0.95	19.45	2	N/A	N/A	19.71	4	22.00	21.94	7.0	N/A	238.1	216.4	239.2	0.9
2308	46	0.99	19.07	2	N/A	N/A	19.58	4	21.14	21.07	N/A	N/A	238.1	218.3	239.2	0.5
Tuff USW G2-1951, Zeolitic																
CO_2 atmosphere, J-13 groundwater, Wet-sieved (75-500 μm), Temperature range: 18–20°C, Data binder: LA-CST-03-94-09 Sample IDs: J-13-G2 1951-C.XXXX-25																
2309	46	1.00	19.66	2	N/A	N/A	19.69	4	21.02	20.94	7.1	N/A	238.1	216.4	239.2	0.7
2310	46	0.99	19.44	2	N/A	N/A	19.60	4	21.08	20.98	N/A	N/A	238.1	219.9	239.2	0.5
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: LA-CST-03-94-09 Sample IDs: J-13 G2-1951 C.XXXX-25																
2363	47	1.01	19.91	2	N/A	N/A	19.90	5	20.54	20.52	N/A	N/A	266.0	248.9	266.9	0.5
2364	47	1.01	19.82	2	8.5	N/A	19.91	5	20.56	20.53	8.3	N/A	266.0	246.5	266.9	0.7

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			Mass of added water (g)	Period (days)	Final pH	Final Eh	Mass of added soln (g)	Period (days)	Soln/solid ratio (mL/g of solid) Initial	Soln/solid ratio (mL/g of solid) Final	Final pH	Final Eh	Alpha activity in soln (cpm/g of soln) Initial	Alpha activity in soln (cpm/g of soln) Final	Alpha activity in soln (cpm/g of soln) Control	
Tuff USW G2-2000, Zeolitic																
CO_2 atmosphere, J-13 groundwater, Wet-sieved (75-500 µm), Temperature range: 18–20°C, Data binder: LA-CST-03-94-09 Sample IDs: J-13-G2 2000-C.XXXX-25																
2311	46	1.00	19.30	2	N/A	N/A	19.74	4	21.08	21.01	7.0	N/A	238.1	217.7	239.2	0.6
2312	46	0.99	18.58	2	N/A	N/A	19.58	4	21.28	21.20	N/A	N/A	238.1	217.4	239.2	0.5
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 µm), Temperature range: 22–25°C, Data binder: LA-CST-03-94-09 Sample IDs: J-13 G2-2000 C.XXXX-25																
2365	47	1.00	19.84	2	N/A	N/A	19.92	5	20.86	20.83	N/A	N/A	266.0	236.9	266.9	2
2365	47	1.01	19.87	2	8.3	N/A	19.86	5	20.58	20.55	8.3	N/A	266.0	237.4	266.9	1
Tuff USW G2-2222, Zeolitic																
CO_2 atmosphere, J-13 groundwater, Wet-sieved (75-500 µm), Temperature range: 18–20°C, Data binder: LA-CST-03-94-09 Sample IDs: J-13-G2 2222-C.XXXX-25																
2313	46	0.99	19.44	2	N/A	N/A	19.52	4	21.00	20.94	7.0	N/A	238.1	220.0	239.2	0.4
2314	46	0.96	18.60	2	N/A	N/A	19.48	4	21.54	21.47	N/A	N/A	238.1	221.6	239.2	0.3
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 µm), Temperature range: 22–25°C, Data binder: LA-CST-03-94-09 Sample IDs: J-13 G2-2222-C.XXXX-25																
2367	47	1.02	19.84	2	N/A	N/A	19.88	5	20.19	20.16	N/A	N/A	266.0	246.9	266.9	0.8
2367	47	1.00	19.81	2	8.6	N/A	19.80	5	20.59	20.56	8.4	N/A	266.0	243.0	266.9	1

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XXXX part of sample ID	Np sorp/ desorp Expt. #	Mass of mineral (g)	Groundwater Pretreatment				Neptunium-237 Solution Sorption Treatment									Distr. Coeff., K_d (mL/g)
			Mass of added water (g)	Period (days)	Final pH	Final Eh	Mass of added soln (g)	Period (days)	Soln/solid ratio (mL/g of solid) Initial	Soln/solid ratio (mL/g of solid) Final	Final pH	Final Eh	Alpha activity in soln (cpm/g of soln) Initial	Alpha activity in soln (cpm/g of soln) Final	Alpha activity in soln (cpm/g of soln) Control	
Tuff USW G4-268, Devitrified																
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-10-93-06 Sample IDs: J-13 G4-268 C.XXXX-20																
3022	32	1.02	19.81	3	8.4	N/A	19.57	4	19.96	20.07	8.2	N/A	256.7	242.9	263.8	0.2
3023	32	0.98	19.72	3	8.3	N/A	19.28	4	20.80	21.30	N/A	N/A	256.7	243.4	263.8	−0.5
3026	32	1.01	19.84	3	8.3	N/A	19.23	4	19.87	19.59	8.3	N/A	11913.3	11757.0	12130.6	−0.3
3027	32	1.03	19.68	3	8.3	N/A	18.85	4	19.42	19.54	N/A	N/A	11913.3	11611.8	12130.6	−0.8
Same as previous heading except: Data binder: LA-CST-03-94-09 and Sample IDs: J-13-G4 268 C.XXXX-25																
2330	45	1.00	19.94	2	N/A	N/A	19.50	4	20.09	20.08	N/A	N/A	255.0	243.9	253.7	0.3
2331	45	1.00	19.98	2	8.5	N/A	19.52	4	20.08	20.07	8.4	N/A	255.0	244.9	253.7	0.3
2334	45	1.01	19.99	2	N/A	N/A	19.77	4	20.16	20.16	N/A	N/A	12956.7	12500.4	12885.8	0.1
2335	45	1.01	20.02	2	8.5	N/A	19.78	4	20.16	20.15	8.5	N/A	12956.7	12492.5	12885.8	0.2

APPENDIX B: NEPTUNIUM BATCH SORPTION EXPERIMENTAL DATA AND RESULTS

XXXX part of sample ID	Np sorp/ desorp Expt. #	Mass of mineral (g)	Groundwater Pretreatment				Neptunium-237 Solution Sorption Treatment									Distr. Coeff., K_d (mL/g)
			Mass of added water (g)	Period (days)	Final pH	Final Eh	Mass of added soln (g)	Period (days)	Soln/solid ratio (mL/g of solid)		Final pH	Final Eh	Alpha activity in soln (cpm/g of soln)			
									Initial	Final			Initial	Final	Control	
Tuff USW G4-270, Devitrified																
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01																
Sample IDs: J-13-G4 270-C.XXXX-20																
68	1	1.00	20.04	14	N/A	N/A	20.05	17	20.81	20.61	N/A	N/A	257.3	240.3	258.8	0.8
223	3	0.99	20.08	15	8.4	235	20.11	22	21.33	21.01	8.4	241	462.7	445.0	476.4	0.1
224	3	1.02	20.06	15	N/A	N/A	20.14	22	20.75	20.54	N/A	N/A	462.7	449.3	476.4	−0.2
395	8	1.00	19.89	5	8.6	213	19.92	2	20.60	20.64	8.6	243	12860.1	12674.6	13219.2	−0.4
396	8	1.01	20.01	5	N/A	N/A	20.00	2	20.45	20.45	N/A	N/A	12860.1	12452.3	13219.2	−0.007
437	9	1.00	19.72	2	8.6	211	20.04	2	20.81	20.70	8.5	189	14779.0	14204.3	14778.3	0.1
438	9	1.00	19.75	2	N/A	N/A	20.07	2	21.17	21.03	N/A	N/A	14779.0	13939.4	14778.3	0.2
569	12	1.03	19.84	2	8.7	217	19.70	3	19.82	19.81	8.3	212	11256.1	10850.1	11333.6	0.04
570	12	1.03	20.23	2	N/A	N/A	19.80	3	19.92	19.91	N/A	N/A	11256.1	10883.9	11333.6	−0.03
Same as previous heading except: Sample IDs: J-13 G4-270-C.XXXX																
627	13	1.00	19.90	2	8.5	234	19.54	3	20.35	20.33	8.4	187	8276.5	8035.8	8600.6	−0.2
628	13	1.00	19.96	2	N/A	N/A	19.54	3	20.27	20.25	N/A	N/A	8276.5	8048.1	8600.6	−0.2
641	13	1.00	20.04	2	8.6	210	19.59	5	20.30	19.71	8.3	184	8276.5	8354.1	8600.6	−0.3
642	13	1.03	20.01	2	N/A	N/A	19.67	5	19.93	19.90	N/A	N/A	8276.5	8310.8	8600.6	−0.9
655	13	1.01	20.00	2	8.4	224	19.76	7	20.37	20.31	8.5	199	8276.5	8304.3	8600.6	−0.8
656	13	1.03	20.00	2	N/A	N/A	19.73	7	19.99	19.94	N/A	N/A	8276.5	8276.2	8600.6	−0.8
669	13	1.03	19.93	2	8.4	227	19.67	14	19.87	19.81	8.5	208	8276.5	8197.3	8620.3	−0.5
670	13	1.00	20.01	2	N/A	N/A	19.68	14	20.45	20.38	N/A	N/A	8276.5	8106.9	8620.3	−0.3
683	13	1.03	20.01	2	8.3	244	19.70	21	19.89	19.77	8.7	90	8276.5	8252.1	8620.3	−0.6
684	13	1.00	19.97	2	N/A	N/A	19.67	21	20.49	20.39	N/A	N/A	8276.5	8221.3	8620.3	−0.6
697	13	1.02	20.04	2	8.4	225	19.58	31	20.00	19.83	8.5	187	8276.5	8173.1	8620.3	−0.4
698	13	1.01	20.01	2	N/A	N/A	19.61	31	20.38	20.21	N/A	N/A	8276.5	8196.8	8620.3	−0.6
Same as previous complete heading except: Sample IDs: G4-270																
none	14	1.00	19.92	6	8.4	196	20.02	23	20.75	20.43	8.5	185	250.5	245.8	255.7	−0.03
none	14	1.01	19.81	6	N/A	N/A	19.99	23	20.50	20.16	N/A	N/A	250.5	243.0	255.7	0.2
Same as previous complete heading except: Sample IDs: J-13-G-4 270-XXX-20																
K-01	K_d sorp time	1.00	19.99	15	8.3	265	20.02	1	21.56	21.58	8.5	213	477.2	452.6	474.4	−0.5
K-02	K_d sorp time	1.01	20.02	15	8.4	N/A	20.04	5	21.21	21.15	N/A	N/A	477.2	441.7	474.4	0.3

APPENDIX B: NEPTUNIUM BATCH SORPTION EXPERIMENTAL DATA AND RESULTS

XXXX part of sample ID	Np sorp/ desorp Expt. #	Mass of mineral (g)	Groundwater Pretreatment				Neptunium-237 Solution Sorption Treatment									Distr. Coeff., K_d (mL/g)
			Mass of added water (g)	Period (days)	Final pH	Final Eh	Mass of added soln (g)	Period (days)	Soln/solid ratio (mL/g of solid)		Final pH	Final Eh	Alpha activity in soln (cpm/g of soln)			
									Initial	Final			Initial	Final	Control	
Tuff USW G4-270, Devitrified (continued)																
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: LA-CST-03-94-09																
Sample IDs: J-13-G4 270C.XXXX-25																
2295	45	1.01	19.88	2	N/A	N/A	19.62	4	19.96	19.95	N/A	N/A	255.0	244.2	253.7	0.3
2296	45	1.01	19.88	2	8.5	N/A	19.70	4	20.11	20.09	8.4	N/A	255.0	240.9	253.7	0.6
2301	45	1.00	19.87	2	N/A	N/A	19.77	4	20.36	20.35	N/A	N/A	12956.7	12537.0	12885.8	0.08
2302	45	1.01	19.91	2	8.6	N/A	19.81	4	20.21	20.20	8.5	N/A	12956.7	12514.6	12885.8	0.1
Air atmosphere, J-13 groundwater, Dry-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01																
Sample IDs: J-13-G-4 270-C.XXXX-20																
16	1	1.01	20.01	15	N/A	N/A	20.20	21	20.56	20.43	N/A	N/A	252.8	236.9	258.7	0.9
171	3	1.01	20.02	14	8.3	238	20.12	21	20.94	20.75	8.5	243	474.5	434.6	473.6	1
172	3	1.00	19.96	14	N/A	N/A	20.13	21	21.31	20.94	N/A	N/A	475.2	434.1	473.6	1
341	6	1.00	19.70	2	8.4	296	19.83	4	20.72	20.66	8.2	214	444.9	417.3	438.6	0.5
342	6	1.00	19.88	2	N/A	N/A	19.97	4	20.78	20.63	N/A	N/A	444.9	418.9	438.6	0.6
Same as previous heading except: Sample IDs: J-13-G-4 270-XXXX-20																
K-01D	K_d sorp time	0.84	19.92	14	8.7	245	19.87	1	24.39	24.33	8.5	202	477.2	443.1	474.4	1
K-02D	K_d sorp time	1.03	19.72	14	8.6	N/A	19.96	5	20.42	20.34	N/A	N/A	477.2	434.7	474.4	0.9
Air atmosphere, UE-25 p#1 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01																
Sample IDs: P-1 G4-270-C.XXXX-20																
301	4	1.01	20.10	13	8.9	191	20.04	21	21.01	20.87	9.0	204	515.4	480.2	528.1	0.4
377	7	1.00	20.06	4	8.9	203	19.99	2	20.71	20.71	8.8	211	2234.8	2214.5	2290.4	−0.5
378	7	1.00	20.10	4	N/A	N/A	20.05	2	20.77	20.79	N/A	N/A	2234.8	2220.1	2290.4	−0.6
449	9	1.00	19.76	2	9.0	174	20.19	2	21.24	21.13	9.0	170	2536.0	2397.1	2559.0	0.2
450	9	1.00	19.73	2	N/A	N/A	20.19	2	21.39	21.18	N/A	N/A	2536.0	2378.9	2559.0	0.3
613	12	1.01	19.99	3	8.9	176	20.15	3	20.73	20.73	9.0	173	1748.7	1688.2	1752.0	−0.07
614	12	1.01	20.00	3	N/A	N/A	20.09	3	20.73	20.73	N/A	N/A	1748.7	1668.0	1752.0	0.1

APPENDIX B: NEPTUNIUM BATCH SORPTION EXPERIMENTAL DATA AND RESULTS

XXXX part of sample ID	Np sorp/ desorp Expt. #	Mass of mineral (g)	Groundwater Pretreatment				Neptunium-237 Solution Sorption Treatment									Distr. Coeff., K_d (mL/g)
			Mass of added water (g)	Period (days)	Final pH	Final Eh	Mass of added soln (g)	Period (days)	Soln/solid ratio (mL/g of solid)		Final pH	Final Eh	Alpha activity in soln (cpm/g of soln)			
									Initial	Final			Initial	Final	Control	
Tuff USW G4-270, Devitrified (continued)																
Air atmosphere, UE-25 p#1 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01																
Sample IDs: P-1 G4-270-C.XXXX																
711	13	1.01	20.03	2	9.0	213	19.85	3	20.42	20.41	8.8	183	1702.9	1657.8	1755.0	−0.2
712	13	1.00	20.06	2	N/A	N/A	20.04	3	20.74	20.72	N/A	N/A	1702.9	1643.3	1755.0	0.05
725	13	1.00	20.14	2	9.0	203	20.01	5	20.73	20.72	9.0	184	1702.9	1667.8	1755.0	−0.3
726	13	1.00	20.02	2	N/A	N/A	20.03	5	21.08	21.04	N/A	N/A	1702.9	1641.5	1755.0	−0.3
739	13	1.00	20.14	2	9.0	189	19.99	7	20.59	20.47	9.0	203	1702.9	1656.6	1755.0	0.08
740	13	1.03	20.13	2	N/A	N/A	20.01	7	20.14	20.12	N/A	N/A	1702.9	1664.8	1755.0	−0.2
753	13	1.01	20.02	2	9.0	196	19.90	14	20.45	20.31	9.1	194	1702.9	1643.1	1766.2	0.1
754	13	1.02	20.01	2	N/A	N/A	19.90	14	20.43	20.38	N/A	N/A	1702.9	1641.8	1766.2	−0.1
767	13	1.01	20.09	2	8.9	156	19.97	21	20.60	20.50	9.1	169	1702.9	1643.5	1766.2	−0.01
768	13	1.02	20.04	2	N/A	N/A	20.13	21	20.32	20.22	N/A	N/A	1702.9	1664.9	1766.2	−0.03
781	13	1.02	20.02	2	8.9	168	19.92	31	20.24	20.06	8.8	147	1702.9	1649.2	1766.2	0.1
782	13	1.00	20.06	2	N/A	N/A	19.71	31	20.64	20.45	N/A	N/A	1702.9	1636.2	1766.2	0.07
Air atmosphere, UE-25 p#1 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: LA-CST-03-94-09																
Sample IDs: P-1-G4 270 C.XXXX-25																
2307	45	1.00	19.30	2	N/A	N/A	19.78	4	20.24	20.23	N/A	N/A	264.6	253.1	263.0	0.5
2308	45	1.01	19.84	2	9.0	N/A	19.82	4	20.14	20.13	8.9	N/A	264.6	252.6	263.0	0.4
2313	45	1.01	19.76	2	N/A	N/A	19.86	4	20.26	20.24	N/A	N/A	1813.3	1742.4	1813.6	0.2
2314	45	1.00	19.73	2	9.0	N/A	19.85	4	20.37	20.35	8.9	N/A	1813.3	1754.8	1813.6	0.2
Air atmosphere, UE-25 p#1 groundwater, Dry-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01																
Sample IDs: P-1 G-4 270-C.XXXX-20																
93	2	1.03	20.03	14	8.9	212	19.87	21	19.54	19.38	9.0	226	220.4	203.7	218.8	1
94	2	1.00	20.09	14	N/A	N/A	20.01	21	20.44	20.30	N/A	N/A	220.4	207.4	218.8	1
249	4	1.00	19.99	13	8.9	203	20.18	21	21.15	21.00	8.8	214	480.9	454.8	512.5	0.3
250	4	1.00	19.85	13	N/A	N/A	20.12	21	20.90	20.73	N/A	N/A	480.9	465.5	512.5	0.06
359	6	1.00	19.96	2	8.9	237	19.96	4	20.57	20.51	8.8	192	478.8	484.4	514.6	−0.8
360	6	1.02	19.96	2	N/A	N/A	19.91	4	20.21	20.11	N/A	N/A	478.8	484.3	514.6	−0.8

APPENDIX B: NEPTUNIUM BATCH SORPTION EXPERIMENTAL DATA AND RESULTS

XXXX part of sample ID	Np sorp/ desorp Expt. #	Mass of mineral (g)	Groundwater Pretreatment				Neptunium-237 Solution Sorption Treatment									Distr. Coeff., K_d (mL/g)
			Mass of added water (g)	Period (days)	Final pH	Final Eh	Mass of added soln (g)	Period (days)	Soln/solid ratio (mL/g of solid)		Final pH	Final Eh	Alpha activity in soln (cpm/g of soln)			
									Initial	Final			Initial	Final	Control	
Tuff USW G4-270, Devitrified (continued)																
CO_2 atmosphere, J-13 groundwater, Wet-sieved (75-500 μm), Temperature range: 18–25°C, Data binder: TWS-INC-10-93-06																
Sample IDs: J-13 G4-270-C.XXXX-25																
2251	43	1.03	19.70	3	7.2	N/A	19.40	3	20.09	20.11	6.9	N/A	247.5	229.9	248.7	0.2
2252	43	1.02	19.68	3	N/A	N/A	19.40	3	20.20	20.22	N/A	N/A	247.5	234.1	248.7	−0.1
2261	43	0.99	19.39	3	7.1	N/A	19.86	3	21.06	21.07	6.7	N/A	11024.1	10524.3	10983.7	−0.06
2262	43	0.98	18.77	3	N/A	N/A	19.83	3	21.20	21.21	N/A	N/A	11024.1	10600.6	10983.7	−0.2
CO_2 atmosphere, UE-25 p#1 groundwater, Wet-sieved (75-500 μm), Temperature range: 19–20°C, Data binder: LA-CST-03-94-09																
Sample IDs: P-1 G4-270-C.XXXX-25																
2271	44	1.00	19.45	2	7.1	N/A	19.96	4	21.27	21.28	7.2	N/A	250.5	232.7	253.1	0.2
2272	44	1.00	19.43	2	N/A	N/A	19.93	4	20.99	21.00	N/A	N/A	250.5	238.2	253.1	−0.04
2281	44	1.02	19.11	2	7.1	N/A	19.70	4	20.04	20.03	7.1	N/A	1757.3	1665.4	1790.7	0.3
2282	44	1.02	19.15	2	N/A	N/A	19.52	4	19.98	19.98	N/A	N/A	1757.3	1698.3	1790.7	−0.2
Tuff USW G4-272, Devitrified																
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-10-93-06																
Sample IDs: J-13 G4-272-C.XXXX-20																
2000	20	1.00	19.93	2	8.3	203	19.99	3	20.61	20.60	8.3	205	291.0	260.4	290.2	2
2001	20	1.00	19.97	2	N/A	N/A	19.99	3	20.58	20.56	N/A	N/A	291.0	265.7	290.2	1
Tuff USW G4-1067																
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01																
Sample IDs: G4-1067																
none	14	1.02	19.85	6	8.1	197	19.96	23	20.26	20.11	8.4	193	250.5	239.1	255.7	0.4
none	14	1.01	19.88	6	N/A	N/A	19.99	23	20.67	20.53	N/A	N/A	250.5	235.2	255.7	0.6

APPENDIX B: NEPTUNIUM BATCH SORPTION EXPERIMENTAL DATA AND RESULTS

XXXX part of sample ID	Np sorp/ desorp Expt. #	Mass of mineral (g)	Groundwater Pretreatment				Neptunium-237 Solution Sorption Treatment									Distr. Coeff., K_d (mL/g)
			Mass of added water (g)	Period (days)	Final pH	Final Eh	Mass of added soln (g)	Period (days)	Soln/solid ratio (mL/g of solid) Initial	Soln/solid ratio (mL/g of solid) Final	Final pH	Final Eh	Alpha activity in soln (cpm/g of soln) Initial	Alpha activity in soln (cpm/g of soln) Final	Alpha activity in soln (cpm/g of soln) Control	
Tuff USW G4-1395																
CO_2 atmosphere, J-13 groundwater, Wet-sieved (75-500 µm), Temperature range: 18-20°C, Data binder: LA-CST-03-94-09 Sample IDs: J-13-G4 1395-C.XXXX-25																
2315	46	0.97	19.47	2	N/A	N/A	19.48	4	21.55	21.46	6.9	N/A	238.1	201.0	239.2	2
2316	46	1.01	19.39	2	N/A	N/A	19.35	4	20.33	20.22	N/A	N/A	238.1	205.0	239.2	2
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 µm), Temperature range: 22-25°C, Data binder: LA-CST-03-94-09 Sample IDs: J-13 G4-1395 C.XXXX-25																
2369	47	1.01	19.79	2	N/A	N/A	19.80	5	20.47	20.44	N/A	N/A	266.0	236.1	266.9	2
2369	47	1.01	19.81	2	8.3	N/A	19.84	5	20.50	20.48	8.3	N/A	266.0	235.7	266.9	2
Tuff USW G4-1505																
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 µm), Temperature range: 22–25°C, Data binder: LA-CST-03-94-09 Sample IDs: J-13-G4 1505C.XXXX-25																
2332	45	1.01	19.94	2	N/A	N/A	19.26	4	19.80	19.79	N/A	N/A	255.0	223.6	253.7	2
2333	45	1.01	19.88	2	8.5	N/A	19.19	4	19.86	19.85	8.5	N/A	255.0	214.0	253.7	3
2336	45	1.01	19.92	2	N/A	N/A	19.74	4	20.33	20.31	N/A	N/A	12956.7	11414.5	12885.8	2
2337	45	1.00	19.91	2	8.5	N/A	19.73	4	20.62	20.60	8.5	N/A	12956.7	11338.5	12885.8	2
Tuff USW G4-1506, Clinoptilolite-rich, Zeolitic																
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 µm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: J-13 G4-1506-C.XXXX-20																
73	1	1.03	20.03	14	8.5	253	20.06	17	20.28	20.07	8.6	349	257.3	214.6	258.8	3
74	1	1.00	19.96	14	N/A	N/A	19.64	17	20.38	20.17	N/A	N/A	257.3	219.6	258.8	3
229	3	1.02	20.00	15	8.2	226	20.08	22	20.92	20.62	8.4	233	462.7	368.1	476.4	4
230	3	1.03	20.05	15	N/A	N/A	20.02	22	20.29	20.04	N/A	N/A	462.7	374.3	476.4	4
397	8	1.01	19.95	5	8.6	299	20.01	2	20.70	20.67	8.5	193	12860.1	11582.0	13219.2	1
398	8	1.01	19.87	5	N/A	N/A	19.94	2	20.61	20.65	N/A	N/A	12860.1	11420.3	13219.2	2
439	9	1.00	19.74	2	8.6	219	20.02	2	21.56	21.44	8.5	197	14779.0	12672.1	14778.3	2
440	9	1.00	19.72	2	N/A	N/A	20.04	2	21.26	21.12	N/A	N/A	14779.0	12839.1	14778.3	2
571	12	1.01	19.98	2	8.5	216	19.96	3	20.73	20.72	8.4	188	11256.1	9569.0	11333.6	3
572	12	1.06	19.97	2	N/A	N/A	20.03	3	19.86	19.85	N/A	N/A	11256.1	9478.3	11333.6	3

APPENDIX B: NEPTUNIUM BATCH SORPTION EXPERIMENTAL DATA AND RESULTS

XXXX part of sample ID	Np sorp/ desorp Expt. #	Mass of mineral (g)	Groundwater Pretreatment				Neptunium-237 Solution Sorption Treatment									Distr. Coeff., K_d (mL/g)
			Mass of added water (g)	Period (days)	Final pH	Final Eh	Mass of added soln (g)	Period (days)	Soln/solid ratio (mL/g of solid) Initial	Soln/solid ratio (mL/g of solid) Final	Final pH	Final Eh	Alpha activity in soln (cpm/g of soln) Initial	Alpha activity in soln (cpm/g of soln) Final	Alpha activity in soln (cpm/g of soln) Control	
Tuff USW G4-1506, Clinoptilolite-rich, Zeolitic (continued)																
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: J-13 G4-1506-C.XXXX																
629	13	1.02	19.93	2	8.3	194	19.54	3	20.23	20.25	8.4	186	8276.5	7094.8	8600.6	2
630	13	1.00	19.93	2	N/A	N/A	19.51	3	20.93	20.92	N/A	N/A	8276.5	7020.7	8600.6	2
643	13	1.03	20.04	2	8.4	224	19.58	5	20.32	20.29	8.5	194	8276.5	7296.3	8600.6	1
644	13	1.01	20.04	2	N/A	N/A	19.72	5	20.66	20.63	N/A	N/A	8276.5	7461.5	8600.6	1
657	13	1.01	19.89	2	8.3	220	19.73	7	20.67	20.61	8.6	189	8276.5	7321.6	8600.6	1
658	13	1.03	19.98	2	N/A	N/A	19.72	7	20.33	20.28	N/A	N/A	8276.5	7245.3	8600.6	2
671	13	1.01	20.00	2	8.4	220	19.67	14	20.50	20.44	8.6	188	8276.5	7321.4	8620.3	2
672	13	1.01	19.97	2	N/A	N/A	19.69	14	20.50	20.43	N/A	N/A	8276.5	7350.3	8620.3	2
685	13	1.02	20.01	2	8.4	233	19.69	21	20.32	20.22	8.6	153	8276.5	7402.7	8620.3	1
686	13	1.03	20.01	2	N/A	N/A	19.56	21	20.22	20.10	N/A	N/A	8276.5	7103.6	8620.3	2
699	13	1.01	20.02	2	8.3	268	19.71	31	20.54	20.33	8.5	160	8276.5	7258.1	8620.3	2
700	13	1.00	20.02	2	N/A	N/A	19.68	31	20.62	20.40	N/A	N/A	8276.5	7374.7	8620.3	2
Same as previous heading except: Data binder: TWS-INC-10-93-06 and Sample IDs: J-13 G4-1506-C.XXXX-20																
2002	20	1.01	19.93	2	8.3	201	20.02	3	20.63	20.63	8.4	213	291.0	238.5	290.2	4
2003	20	1.00	19.96	2	N/A	N/A	20.02	3	20.85	20.85	N/A	N/A	291.0	241.9	290.2	3
Same as previous complete heading except: Sample IDs: J-13-G-4 1506-XXX-20																
K-03	K_d sorp time	1.01	19.85	15	8.4	267	20.07	1	21.17	21.11	8.5	208	477.2	381.0	474.4	4
K-04	K_d sorp time	1.02	19.86	15	8.3	N/A	19.98	5	20.98	20.90	N/A	N/A	477.2	370.4	474.4	4
Air atmosphere, J-13 groundwater, Dry-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: J-13-G-4 1506-C.XXXX-20																
17	1	1.01	20.01	15	8.4	292	20.23	21	21.09	20.92	8.6	254	252.8	198.8	258.7	5
18	1	1.00	20.01	15	N/A	N/A	20.28	21	21.08	20.94	N/A	N/A	252.8	195.8	258.7	5
173	3	1.03	19.94	14	8.5	241	20.06	21	20.69	20.52	8.4	236	474.5	347.1	473.6	6
174	3	1.03	19.97	14	N/A	N/A	20.01	21	21.27	21.13	N/A	N/A	474.5	335.2	473.6	6
343	6	1.01	19.70	2	8.3	208	19.88	4	20.64	20.53	8.2	216	444.9	365.2	438.6	3
344	6	1.00	19.83	2	N/A	N/A	20.60	4	21.80	21.67	N/A	N/A	444.9	360.3	438.6	4

APPENDIX B: NEPTUNIUM BATCH SORPTION EXPERIMENTAL DATA AND RESULTS

XXXX part of sample ID	Np sorp/ desorp Expt. #	Mass of mineral (g)	Groundwater Pretreatment				Neptunium-237 Solution Sorption Treatment									Distr. Coeff., K_d (mL/g)
			Mass of added water (g)	Period (days)	Final pH	Final Eh	Mass of added soln (g)	Period (days)	Soln/solid ratio (mL/g of solid)		Final pH	Final Eh	Alpha activity in soln (cpm/g of soln)			
									Initial	Final			Initial	Final	Control	
Tuff USW G4-1506, Clinoptilolite-rich, Zeolitic (continued)																
Air atmosphere, UE-25 p#1 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01																
Sample IDs: P-1-G-4 1506-C.XXXX-20																
151	2	1.01	19.96	14	9.1	197	19.97	24	21.01	20.70	8.9	206	217.4	201.6	222.3	0.6
152	2	0.99	19.91	14	N/A	N/A	20.00	24	21.52	21.30	N/A	N/A	217.4	198.2	222.3	0.9
307	4	1.03	19.90	13	8.9	205	19.95	21	20.61	20.45	9.0	218	515.4	472.6	528.1	0.7
308	4	1.04	19.94	13	N/A	N/A	20.03	21	20.50	20.34	N/A	N/A	515.4	473.1	528.1	0.6
379	7	1.00	20.09	4	8.8	181	20.14	2	21.22	21.27	8.8	150	2234.8	2140.6	2290.4	−0.2
380	7	1.00	20.12	4	N/A	N/A	19.92	2	20.92	20.97	N/A	N/A	2234.8	2156.7	2290.4	−0.3
615	12	1.01	19.94	3	8.9	171	20.18	3	21.03	21.02	9.0	172	1748.7	1643.1	1752.0	0.2
616	12	1.01	19.97	3	N/A	N/A	20.01	3	21.13	21.13	N/A	N/A	1748.7	1618.3	1752.0	0.3
Same as previous heading except: Sample IDs: P-1 G4-1506-C.XXXX																
713	13	1.03	20.07	2	9.1	204	20.11	3	20.40	20.40	8.8	182	1702.9	1610.0	1755.0	0.2
714	13	1.01	20.06	2	N/A	N/A	20.10	3	20.90	20.90	N/A	N/A	1702.9	1608.6	1755.0	0.2
727	13	1.03	19.99	2	9.0	180	20.06	5	20.40	20.35	9.0	174	1702.9	1640.6	1755.0	−0.1
728	13	1.00	20.05	2	N/A	N/A	20.09	5	21.40	21.38	N/A	N/A	1702.9	1620.8	1755.0	−0.3
741	13	1.02	20.01	2	9.0	207	19.86	7	20.46	20.44	9.0	197	1702.9	1629.0	1755.0	−0.09
742	13	1.00	19.90	2	N/A	N/A	19.94	7	21.12	21.08	N/A	N/A	1702.9	1612.7	1755.0	−0.03
755	13	1.01	19.98	2	9.1	193	19.78	14	20.54	20.48	9.1	191	1702.9	1620.4	1766.2	0.1
756	13	1.00	20.02	2	N/A	N/A	19.73	14	20.78	20.72	N/A	N/A	1702.9	1617.6	1766.2	0.05
769	13	1.02	20.10	2	8.9	150	20.02	21	20.54	20.45	9.0	164	1702.9	1630.9	1766.2	0.05
770	13	1.00	20.24	2	N/A	N/A	19.98	21	20.95	20.85	N/A	N/A	1702.9	1630.3	1766.2	0.01
783	13	1.01	20.03	2	8.9	171	17.87	31	18.69	18.50	9.0	170	1702.9	1608.4	1766.2	0.2
784	13	1.00	20.01	2	N/A	N/A	19.78	31	20.79	20.60	N/A	N/A	1702.9	1611.9	1766.2	0.3
Air atmosphere, UE-25 p#1 groundwater, Dry-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01																
Sample IDs: P-1-G-4 1506-C.XXXX-20																
95	2	1.01	20.21	14	8.9	210	20.12	21	20.99	20.86	8.9	234	220.4	196.2	218.8	2
96	2	1.03	19.96	14	N/A	N/A	20.12	21	20.60	20.26	N/A	N/A	220.4	198.5	218.8	1
251	4	1.01	20.05	13	8.6	205	20.14	21	22.10	21.96	8.9	245	480.9	442.2	512.5	−0.3
252	4	1.00	20.06	13	N/A	N/A	20.14	21	21.58	21.42	N/A	N/A	480.9	456.5	512.5	−0.2
361	6	1.00	20.01	2	9.0	165	19.97	4	21.03	20.96	8.8	163	478.8	470.6	514.6	−0.6
362	6	1.00	19.99	2	N/A	N/A	20.04	4	20.96	20.81	N/A	N/A	478.8	472.2	514.6	−0.5

APPENDIX B: NEPTUNIUM BATCH SORPTION EXPERIMENTAL DATA AND RESULTS

XXXX part of sample ID	Np sorp/ desorp Expt. #	Mass of mineral (g)	Groundwater Pretreatment				Neptunium-237 Solution Sorption Treatment									Distr. Coeff., K_d (mL/g)
			Mass of added water (g)	Period (days)	Final pH	Final Eh	Mass of added soln (g)	Period (days)	Soln/solid ratio (mL/g of solid) Initial	Soln/solid ratio (mL/g of solid) Final	Final pH	Final Eh	Alpha activity in soln (cpm/g of soln) Initial	Alpha activity in soln (cpm/g of soln) Final	Alpha activity in soln (cpm/g of soln) Control	
Tuff USW G4-1510, Clinoptilolite-rich, Zeolitic																
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: LA-CST-03-94-09 Sample IDs: J-13-G4 1510C.XXXX-25																
2291	45	1.01	19.71	2	N/A	N/A	19.79	4	20.42	20.41	N/A	N/A	255.0	222.5	253.7	2
2292	45	1.01	19.86	2	8.4	N/A	19.80	4	20.38	20.37	8.4	N/A	255.0	223.1	253.7	2
2297	45	1.03	19.89	2	N/A	N/A	19.81	4	19.91	19.89	N/A	N/A	12956.7	11704.5	12885.8	1
2298	45	1.01	19.86	2	8.5	N/A	19.83	4	20.42	20.41	8.3	N/A	12956.7	11740.8	12885.8	1
Air atmosphere, UE-25 p#1 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: LA-CST-03-94-09 Sample IDs: P-1-G4 1510C.XXXX-25																
2303	45	1.01	19.80	2	N/A	N/A	19.80	4	20.33	20.32	N/A	N/A	264.6	249.6	263.0	0.5
2304	45	1.00	19.76	2	8.9	N/A	19.84	4	20.61	20.60	8.9	N/A	264.6	250.0	263.0	0.4
2309	45	1.00	19.77	2	N/A	N/A	19.75	4	20.48	20.45	N/A	N/A	1813.3	1715.9	1813.6	0.4
2310	45	1.01	19.84	2	8.9	N/A	19.76	4	20.32	20.30	8.9	N/A	1813.3	1711.8	1813.6	0.4
CO_2 atmosphere, J-13 groundwater, Wet-sieved (75-500 μm), Temperature range: 18–25°C, Data binder: TWS-INC-10-93-06 Sample IDs: J-13 G4-1510-C.XXXX-25																
2253	43	0.99	19.74	3	7.1	N/A	17.69	3	19.72	19.76	6.8	N/A	247.5	177.2	248.7	5
2254	43	1.04	19.67	3	N/A	N/A	19.29	3	20.05	20.08	N/A	N/A	247.5	182.5	248.7	5
2263	43	1.00	19.18	3	7.0	N/A	19.81	3	21.10	21.12	6.8	N/A	11024.1	9306.1	10983.7	2
2264	43	0.99	19.28	3	N/A	N/A	19.90	3	21.28	21.30	N/A	N/A	11024.1	9633.1	10983.7	2
CO_2 atmosphere, UE-25 p#1 groundwater, Wet-sieved (75-500 μm), Temperature range: 19–20°C, Data binder: LA-CST-03-94-09 Sample IDs: P-1 G4-1510-C.XXXX-25																
2273	44	1.00	19.33	2	7.0	N/A	19.94	4	20.79	20.79	7.1	N/A	250.5	234.8	253.1	0.5
2274	44	1.01	19.21	2	N/A	N/A	19.58	4	20.63	20.63	N/A	N/A	250.5	233.4	253.1	0.2
2283	44	0.99	19.05	2	7.1	N/A	19.26	4	20.37	20.78	7.0	N/A	1757.3	1662.2	1790.7	−0.2
2284	44	1.02	19.10	2	N/A	N/A	19.76	4	20.33	20.33	N/A	N/A	1757.3	1695.4	1790.7	−0.3

APPENDIX B: NEPTUNIUM BATCH SORPTION EXPERIMENTAL DATA AND RESULTS

XXXX part of sample ID	Np sorp/ desorp Expt. #	Mass of mineral (g)	Groundwater Pretreatment				Neptunium-237 Solution Sorption Treatment									Distr. Coeff., K_d (mL/g)
			Mass of added water (g)	Period (days)	Final pH	Final Eh	Mass of added soln (g)	Period (days)	Soln/solid ratio (mL/g of solid)		Final pH	Final Eh	Alpha activity in soln (cpm/g of soln)			
									Initial	Final			Initial	Final	Control	
Tuff USW G4-1529, Zeolitic																
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: J-13 G4-1529-C.XXXX-20																
499	11	1.00	19.96	2	8.8	130	20.03	2	21.05	20.98	8.6	181	11304.8	10542.8	11075.1	0.5
500	11	1.00	19.93	2	N/A	N/A	19.99	2	20.86	20.80	N/A	N/A	11304.8	10344.8	11075.1	1
559	12	1.03	19.97	2	9.2	156	19.97	3	20.41	20.41	8.3	186	11256.1	9894.8	11333.6	2
560	12	1.05	19.95	2	N/A	N/A	19.98	3	20.01	20.00	N/A	N/A	11256.1	9985.8	11333.6	1
Same as previous heading except: Data binder: TWS-INC-10-93-06																
2022	20	1.01	19.99	3	8.4	199	20.07	3	20.58	20.58	8.4	197	291.0	263.2	290.2	1
2023	20	1.00	20.00	3	N/A	N/A	20.00	3	20.73	20.73	N/A	N/A	291.0	260.1	290.2	2
Air atmosphere, UE-25 p#1 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: P-1 G4-1529-C.XXXX-20																
529	11	1.00	19.95	3	8.9	128	20.07	2	21.02	21.00	9.0	151	1851.1	1730.9	1823.5	0.5
530	11	1.00	19.96	3	N/A	N/A	20.06	2	21.06	21.05	N/A	N/A	1851.1	1699.7	1823.5	0.8
603	12	1.03	19.93	3	8.9	171	20.09	3	20.28	20.29	9.0	166	1748.7	1659.8	1752.0	0.3
604	12	1.05	19.95	3	N/A	N/A	20.02	3	20.11	20.12	N/A	N/A	1748.7	1641.5	1752.0	0.2
Tuff USW G4-1566																
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: G4-1566																
none	14	1.02	19.81	6	8.2	202	19.96	23	20.46	20.33	8.5	180	250.5	202.2	255.7	4
none	14	1.00	19.80	6	N/A	N/A	20.14	23	21.04	20.76	N/A	N/A	250.5	207.0	255.7	4

APPENDIX B: NEPTUNIUM BATCH SORPTION EXPERIMENTAL DATA AND RESULTS

XXXX part of sample ID	Np sorp/ desorp Expt. #	Mass of mineral (g)	Groundwater Pretreatment				Neptunium-237 Solution Sorption Treatment									Distr. Coeff., K_d (mL/g)
			Mass of added water (g)	Period (days)	Final pH	Final Eh	Mass of added soln (g)	Period (days)	Soln/solid ratio (mL/g of solid)		Final pH	Final Eh	Alpha activity in soln (cpm/g of soln)			
									Initial	Final			Initial	Final	Control	
Tuff USW G4-1625																
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: J-13 G4-1625-C.XXXX-20																
501	11	1.00	19.91	2	8.8	130	20.00	2	21.08	20.99	8.6	180	11304.8	9978.4	11075.1	2
502	11	1.00	19.90	2	N/A	N/A	20.04	2	21.63	21.56	N/A	N/A	11304.8	9907.4	11075.1	1
561	12	1.00	19.98	2	9.2	172	20.03	3	21.07	21.06	8.3	191	11256.1	9527.0	11333.6	3
562	12	1.02	20.11	2	N/A	N/A	19.97	3	20.60	20.58	N/A	N/A	11256.1	9565.7	11333.6	2
Same as previous heading except: Data binder: TWS-INC-10-93-06																
2024	20	1.02	20.03	3	8.4	203	19.99	3	20.47	20.47	8.4	210	291.0	248.1	290.2	3
2025	20	1.00	19.91	3	N/A	N/A	19.98	3	20.85	20.84	N/A	N/A	291.0	249.8	290.2	2
Air atmosphere, UE-25 p#1 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: P-1 G4-1625-C.XXXX-20																
531	11	1.00	19.91	3	8.9	131	20.08	2	21.03	21.03	8.9	147	1851.1	1674.9	1823.5	1
532	11	1.00	19.94	3	N/A	N/A	20.02	2	21.38	21.37	N/A	N/A	1851.1	1684.5	1823.5	0.6
605	12	1.00	19.97	3	8.9	170	20.11	3	20.89	20.88	9.0	171	1748.7	1665.1	1752.0	0.2
606	12	1.01	20.04	3	N/A	N/A	20.02	3	20.61	20.60	N/A	N/A	1748.7	1663.4	1752.0	0.2
Tuff USW G4-1772																
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: J-13 G4-1772-C.XXXX-20																
503	11	1.00	19.89	2	8.8	134	20.03	2	21.03	20.93	8.6	177	11304.8	10088.6	11075.1	2
504	11	1.00	19.99	2	N/A	N/A	20.06	2	21.03	20.96	N/A	N/A	11304.8	9947.2	11075.1	2
563	12	1.01	19.92	2	8.6	199	20.01	3	20.76	20.75	8.2	206	11256.1	9741.1	11333.6	2
564	12	1.02	20.02	2	N/A	N/A	20.00	3	20.59	20.57	N/A	N/A	11256.1	9565.4	11333.6	3
Same as previous heading except: Data binder: TWS-INC-10-93-06																
2026	20	1.00	19.95	3	8.3	213	20.06	3	21.01	21.01	8.4	211	291.0	249.8	290.2	2
2027	20	1.01	19.90	3	N/A	N/A	19.99	3	20.68	20.68	N/A	N/A	291.0	246.9	290.2	3
Air atmosphere, UE-25 p#1 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: P-1 G4-1772-C.XXXX-20																
533	11	1.00	19.85	3	9.0	137	20.08	2	20.98	20.97	8.9	147	1851.1	1713.3	1823.5	0.7
534	11	1.00	19.86	3	N/A	N/A	20.06	2	20.96	20.95	N/A	N/A	1851.1	1721.9	1823.5	0.6
607	12	1.00	19.81	3	8.9	167	20.06	3	21.00	20.99	8.9	170	1748.7	1633.9	1752.0	0.5
608	12	1.03	19.81	3	N/A	N/A	20.14	3	20.59	20.60	N/A	N/A	1748.7	1631.3	1752.0	0.4

APPENDIX B: NEPTUNIUM BATCH SORPTION EXPERIMENTAL DATA AND RESULTS

XXXX part of sample ID	Np sorp/ desorp Expt. #	Mass of mineral (g)	Groundwater Pretreatment				Neptunium-237 Solution Sorption Treatment									Distr. Coeff., K_d (mL/g)
			Mass of added water (g)	Period (days)	Final pH	Final Eh	Mass of added soln (g)	Period (days)	Soln/solid ratio (mL/g of solid) Initial	Soln/solid ratio (mL/g of solid) Final	Final pH	Final Eh	Alpha activity in soln (cpm/g of soln) Initial	Alpha activity in soln (cpm/g of soln) Final	Alpha activity in soln (cpm/g of soln) Control	
Tuff USW G4-2077																
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01																
Sample IDs: J-13 G4-2077-C.XXXX-20																
505	11	1.00	19.94	2	8.5	152	19.99	2	20.84	20.75	8.5	182	11304.8	10543.1	11075.1	0.7
506	11	1.00	19.89	2	N/A	N/A	19.99	2	20.74	20.66	N/A	N/A	11304.8	10573.8	11075.1	0.7
565	12	1.03	19.97	2	8.5	224	19.91	3	20.30	20.29	8.3	211	11256.1	10460.5	11333.6	0.5
566	12	1.02	19.94	2	N/A	N/A	19.93	3	20.48	20.47	N/A	N/A	11256.1	10560.8	11333.6	0.4
Same as previous heading except: Data binder: TWS-INC-10-93-06																
2028	20	1.00	19.90	3	8.3	222	19.99	3	20.65	20.65	8.4	207	291.0	269.3	290.2	1
2029	20	1.00	19.92	3	N/A	N/A	19.95	3	20.58	20.57	N/A	N/A	291.0	268.7	290.2	1
Air atmosphere, UE-25 p#1 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01																
Sample IDs: P-1 G4-2077-C.XXXX-20																
535	11	1.00	19.90	3	8.7	149	20.03	2	20.89	20.87	8.8	154	1851.1	1709.5	1823.5	0.8
536	11	1.00	19.95	3	N/A	N/A	20.01	2	20.73	20.72	N/A	N/A	1851.1	1719.4	1823.5	0.8
609	12	1.06	20.07	3	8.5	190	19.95	3	19.80	19.82	8.8	166	1748.7	1614.8	1752.0	0.6
610	12	1.06	20.04	3	N/A	N/A	20.01	3	19.64	19.68	N/A	N/A	1748.7	1627.1	1752.0	0.6
Tuff USW G4-2570																
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01																
Sample IDs: J-13 G4-2570-C.XXXX-20																
507	11	1.00	19.85	2	8.6	150	20.10	2	20.82	20.67	8.5	181	11304.8	10742.7	11075.1	0.5
508	11	1.00	19.95	2	N/A	N/A	20.34	2	21.09	20.64	N/A	N/A	11304.8	10792.7	11075.1	0.7
567	12	1.05	20.17	2	8.5	218	19.73	3	19.52	19.51	8.3	214	11256.1	10725.1	11333.6	0.2
568	12	1.00	21.15	2	N/A	N/A	19.88	3	20.94	20.93	N/A	N/A	11256.1	10665.7	11333.6	0.05
Same as previous heading except: Data binder: TWS-INC-10-93-06																
2030	20	1.01	19.95	3	8.4	228	19.96	3	20.50	20.50	8.4	234	291.0	274.2	290.2	0.5
2031	20	1.01	19.95	3	N/A	N/A	19.95	3	20.38	20.37	N/A	N/A	291.0	274.6	290.2	0.6
Air atmosphere, UE-25 p#1 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01																
Sample IDs: P-1 G4-2570-C.XXXX-20																
537	11	1.00	19.95	3	9.0	149	20.09	2	20.91	20.89	8.9	153	1851.1	1725.0	1823.5	0.7
538	11	1.00	19.87	3	N/A	N/A	19.98	2	20.84	20.83	N/A	N/A	1851.1	1715.2	1823.5	0.7
611	12	1.03	20.01	3	8.9	177	20.05	3	20.29	20.31	8.9	158	1748.7	1636.3	1752.0	0.5
612	12	1.00	20.01	3	N/A	N/A	20.01	3	20.93	20.94	N/A	N/A	1748.7	1661.1	1752.0	0.1

APPENDIX B: NEPTUNIUM BATCH SORPTION EXPERIMENTAL DATA AND RESULTS

XXXX part of sample ID	Np sorp/ desorp Expt. #	Mass of mineral (g)	Groundwater Pretreatment				Neptunium-237 Solution Sorption Treatment									Distr. Coeff., K_d (mL/g)
			Mass of added water (g)	Period (days)	Final pH	Final Eh	Mass of added soln (g)	Period (days)	Soln/solid ratio (mL/g of solid) Initial	Soln/solid ratio (mL/g of solid) Final	Final pH	Final Eh	Alpha activity in soln (cpm/g of soln) Initial	Alpha activity in soln (cpm/g of soln) Final	Alpha activity in soln (cpm/g of soln) Control	
Tuff USW GU3-747																
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: J-13 GU3-747-C.XXXX-20																
487	11	1.00	19.89	2	8.5	141	20.00	2	20.74	20.69	8.5	185	11304.8	10711.6	11075.1	0.4
488	11	1.00	19.96	2	N/A	N/A	19.98	2	20.97	20.89	N/A	N/A	11304.8	10562.8	11075.1	0.5
547	12	1.02	19.78	2	8.5	217	19.81	3	20.31	20.30	8.4	192	11256.1	10664.7	11333.6	0.2
548	12	1.06	19.72	2	N/A	N/A	19.84	3	19.69	19.69	N/A	N/A	11256.1	10579.8	11333.6	0.2
Same as previous heading except: Data binder: TWS-INC-10-93-06																
2012	20	1.01	19.95	2	8.4	201	19.92	3	20.38	20.37	8.4	218	291.0	272.4	290.2	0.7
2013	20	1.01	19.91	2	N/A	N/A	19.95	3	20.39	20.39	N/A	N/A	291.0	272.0	290.2	0.7
Air atmosphere, UE-25 p#1 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: P-1 GU3-747-C.XXXX-20																
517	11	1.00	19.96	3	8.9	135	20.06	2	20.81	20.80	8.9	159	1851.1	1739.5	1823.5	0.5
518	11	1.00	19.90	3	N/A	N/A	20.09	2	20.85	20.84	N/A	N/A	1851.1	1753.1	1823.5	0.4
591	12	1.01	19.95	3	8.9	178	20.04	3	20.69	20.70	9.0	162	1748.7	1673.0	1752.0	0.04
592	12	1.01	19.92	3	N/A	N/A	20.02	3	20.61	20.63	N/A	N/A	1748.7	1690.3	1752.0	−0.1
Tuff USW GU3-1249																
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: J-13 GU3-1249-C.XXXX-20																
489	11	1.00	19.83	2	8.5	143	19.97	2	20.61	20.54	8.5	191	11304.8	10939.6	11075.1	0.1
490	11	1.00	18.95	2	N/A	N/A	19.92	2	19.68	19.64	N/A	N/A	11304.8	10846.8	11075.1	1
549	12	1.00	20.13	2	8.5	210	19.86	3	20.49	20.48	8.4	193	11256.1	10918.0	11333.6	−0.005
550	12	1.04	20.13	2	N/A	N/A	19.86	3	19.74	19.73	N/A	N/A	11256.1	10890.2	11333.6	0.007
Same as previous heading except: Data binder: TWS-INC-10-93-06																
2014	20	1.02	19.81	2	8.3	210	19.85	3	19.98	19.98	8.5	223	291.0	283.8	290.2	−0.02
2015	20	1.01	19.80	2	N/A	N/A	19.83	3	20.10	20.10	N/A	N/A	291.0	286.0	290.2	−0.1
Air atmosphere, UE-25 p#1 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: P-1 GU3-1249-C.XXXX-20																
519	11	1.00	19.94	3	8.9	132	20.00	2	20.61	20.60	8.9	160	1851.1	1773.7	1823.5	0.3
520	11	1.00	19.93	3	N/A	N/A	20.09	2	20.90	20.88	N/A	N/A	1851.1	1746.4	1823.5	0.4
593	12	1.01	19.70	3	8.9	178	20.04	3	20.51	20.51	9.0	172	1748.7	1721.2	1752.0	−0.4
594	12	1.01	19.75	3	N/A	N/A	20.03	3	20.51	20.52	N/A	N/A	1748.7	1714.6	1752.0	−0.3

APPENDIX B: NEPTUNIUM BATCH SORPTION EXPERIMENTAL DATA AND RESULTS

XXXX part of sample ID	Np sorp/ desorp Expt. #	Mass of mineral (g)	Groundwater Pretreatment				Neptunium-237 Solution Sorption Treatment									Distr. Coeff., K_d (mL/g)
			Mass of added water (g)	Period (days)	Final pH	Final Eh	Mass of added soln (g)	Period (days)	Soln/solid ratio (mL/g of solid) Initial	Soln/solid ratio (mL/g of solid) Final	Final pH	Final Eh	Alpha activity in soln (cpm/g of soln) Initial	Alpha activity in soln (cpm/g of soln) Final	Alpha activity in soln (cpm/g of soln) Control	
Tuff USW GU3-1394																
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: J-13 GU3-1394-C.XXXX-20-LC																
317	5	1.01	19.74	13	8.7	237	20.04	22	21.00	20.78	8.5	225	250.7	232.8	250.8	0.6
318	5	1.01	19.96	13	N/A	N/A	20.10	22	20.75	20.64	N/A	N/A	250.7	234.8	250.8	0.6
Same as previous heading except: Sample IDs: J-13-GU3 1394-C.XXXX-20-HC																
320	5	1.00	19.98	13	N/A	N/A	20.16	22	21.10	20.91	N/A	N/A	471.0	445.8	471.4	0.4
Air atmosphere, J-13 groundwater, Dry-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: J-13-GU3 1394-C.XXXX-20																
345	6	1.00	19.66	2	8.2	194	19.95	4	21.01	20.99	8.2	216	444.9	411.9	438.6	0.6
346	6	1.00	19.84	2	N/A	N/A	19.94	4	20.82	20.76	N/A	N/A	444.9	409.9	438.6	0.9
Same as previous heading except: Wet-sieved (75-500 μm)																
399	8	1.00	19.91	5	8.4	231	19.86	2	20.78	20.84	8.5	224	12860.1	12690.3	13219.2	−0.7
400	8	1.01	19.82	5	N/A	N/A	19.97	2	20.64	20.68	N/A	N/A	12860.1	12518.5	13219.2	−0.4
441	9	1.00	19.73	2	8.5	224	20.06	2	21.00	20.87	8.5	212	14779.0	13978.9	14778.3	0.3
442	9	1.00	19.69	2	N/A	N/A	19.99	2	20.84	20.73	N/A	N/A	14779.0	14077.4	14778.3	0.3
Same as previous complete heading except: Wet-sieved (75-500 μm), Data binder: TWS-INC-10-93-06, and Sample IDs: J-13 Gu3-1394-C.XXXX-20																
2032	20	1.00	19.86	3	8.4	230	19.87	3	20.66	20.65	8.4	238	291.0	269.4	290.2	0.8
2033	20	1.01	19.85	3	N/A	N/A	19.89	3	20.50	20.50	N/A	N/A	291.0	273.4	290.2	0.5
Air atmosphere, UE-25 p#1 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: P-1-GU3 1394-C.XXXX-20-LC																
325	5	1.03	20.00	13	9.0	228	20.09	22	20.28	19.98	8.9	218	222.8	209.7	222.1	0.7
326	5	1.05	20.03	13	N/A	N/A	20.32	22	20.05	19.93	N/A	N/A	222.8	208.0	222.1	0.8
Same as previous heading except: Sample IDs: P-1-GU3 1394-C.XXXX-20-HC																
327	5	1.00	19.99	13	9.0	249	19.99	22	20.73	20.29	8.8	184	515.1	474.4	519.6	1
328	5	1.01	19.99	13	N/A	N/A	20.04	22	20.75	20.71	N/A	N/A	515.1	470.8	519.6	1
Air atmosphere, UE-25 p#1 groundwater, Dry-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: P-1-Gu3 1394-C.XXXX-20																
363	6	1.00	19.77	2	8.9	242	19.97	4	20.88	20.79	8.8	230	478.8	475.7	514.6	−0.7
364	6	1.01	20.02	2	N/A	N/A	19.93	4	20.54	20.39	N/A	N/A	478.8	477.0	514.6	−0.6
Same as previous heading except: Wet-sieved (75-500 μm) and Sample IDs: P-1-GU3 1394-C.XXXX-20																
381	7	1.00	19.85	4	8.9	187	20.10	2	20.95	21.02	9.0	183	2234.8	2172.1	2290.4	−0.3
382	7	1.00	20.08	4	N/A	N/A	20.02	2	21.07	21.07	N/A	N/A	2234.8	2147.9	2290.4	−0.2

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XXXX part of sample ID	Np sorp/ desorp Expt. #	Mass of mineral (g)	Groundwater Pretreatment				Neptunium-237 Solution Sorption Treatment									Distr. Coeff., K_d (mL/g)
			Mass of added water (g)	Period (days)	Final pH	Final Eh	Mass of added soln (g)	Period (days)	Soln/solid ratio (mL/g of solid) Initial	Soln/solid ratio (mL/g of solid) Final	Final pH	Final Eh	Alpha activity in soln (cpm/g of soln) Initial	Alpha activity in soln (cpm/g of soln) Final	Alpha activity in soln (cpm/g of soln) Control	
Tuff USW GU3-1405, Vitric																
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-10-93-06																
Sample IDs: J-13 GU3-1405-C.XXXX-20																
3020	32	0.99	19.91	3	8.5	N/A	19.41	4	20.51	20.53	8.2	N/A	256.7	239.2	263.8	0.5
3021	32	1.02	19.83	3	8.4	N/A	19.51	4	20.12	20.00	N/A	N/A	256.7	239.5	263.8	0.5
3024	32	1.01	19.82	3	8.4	N/A	18.99	4	19.82	20.22	8.2	N/A	11913.3	11616.0	12130.6	−0.9
3025	32	0.98	19.80	3	8.4	N/A	18.95	4	20.54	20.36	N/A	N/A	11913.3	11502.3	12130.6	−0.3
Tuff USW GU3-1407, Vitric																
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01																
Sample IDs: J-13 GU3-1407-C.XXXX-20																
491	11	1.00	19.94	2	8.5	144	19.97	2	21.04	20.99	8.5	195	11304.8	10558.6	11075.1	0.4
492	11	1.00	19.98	2	N/A	N/A	19.93	2	21.03	21.00	N/A	N/A	11304.8	10581.5	11075.1	0.3
551	12	1.04	20.15	2	8.5	231	19.89	3	19.96	19.96	8.4	198	11256.1	10625.2	11333.6	0.3
552	12	1.04	20.05	2	N/A	N/A	19.89	3	20.04	20.03	N/A	N/A	11256.1	10556.5	11333.6	0.4
Same as previous heading except: Sample IDs: J-13 GU3-1407-C.XXXX																
631	13	1.01	20.00	2	8.3	212	19.55	3	20.35	20.21	8.3	207	8276.5	7880.9	8600.6	0.1
632	13	1.01	19.99	2	N/A	N/A	19.72	3	20.77	20.77	N/A	N/A	8276.5	7777.8	8600.6	−0.0008
645	13	1.01	20.03	2	8.3	215	19.58	5	20.31	20.29	8.4	213	8276.5	8156.0	8600.6	−0.6
646	13	1.02	20.01	2	N/A	N/A	19.59	5	20.20	20.18	N/A	N/A	8276.5	8141.2	8600.6	−0.7
659	13	1.02	19.99	2	8.4	229	19.69	7	20.35	20.31	8.6	231	8276.5	8053.2	8600.6	−0.5
660	13	1.00	19.97	2	N/A	N/A	19.72	7	20.64	20.56	N/A	N/A	8276.5	8133.5	8600.6	−0.5
673	13	1.02	19.97	2	8.3	232	19.39	14	19.95	19.87	8.5	215	8276.5	7954.0	8620.3	−0.09
674	13	1.03	20.00	2	N/A	N/A	19.64	14	19.86	19.80	N/A	N/A	8276.5	8061.3	8620.3	−0.2
687	13	1.02	20.00	2	8.3	243	19.35	21	20.07	19.97	8.6	164	8276.5	8014.3	8620.3	−0.4
688	13	1.02	20.02	2	N/A	N/A	19.64	21	20.21	19.86	N/A	N/A	8276.5	8126.4	8620.3	−0.2
701	13	1.03	20.01	2	8.3	249	19.37	31	19.77	19.57	8.5	178	8276.5	8010.6	8620.3	−0.1
702	13	1.00	20.07	2	N/A	N/A	19.60	31	20.60	20.39	N/A	N/A	8276.5	7995.7	8620.3	−0.1
Same as previous complete heading except: Data binder: TWS-INC-10-93-06 and Sample IDs: J-13 Gu3-1407-C.XXXX-20																
2004	20	1.01	20.03	2	8.3	218	20.00	3	20.55	20.55	8.4	207	291.0	267.4	290.2	1
2005	20	1.00	20.01	2	N/A	N/A	20.01	3	20.70	20.69	N/A	N/A	291.0	273.5	290.2	0.6

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XXXX part of sample ID	Np sorp/ desorp Expt. #	Mass of mineral (g)	Groundwater Pretreatment				Neptunium-237 Solution Sorption Treatment									Distr. Coeff., K_d (mL/g)
			Mass of added water (g)	Period (days)	Final pH	Final Eh	Mass of added soln (g)	Period (days)	Soln/solid ratio (mL/g of solid) Initial	Soln/solid ratio (mL/g of solid) Final	Final pH	Final Eh	Alpha activity in soln (cpm/g of soln) Initial	Alpha activity in soln (cpm/g of soln) Final	Alpha activity in soln (cpm/g of soln) Control	
Tuff USW GU3-1407, Vitric (continued)																
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 µm), Temperature range: 22–25°C, Data binder: LA-CST-03-94-09 Sample IDs: J-13-GU3 1407C.XXXX-25																
2293	45	1.03	19.79	2	N/A	N/A	19.74	4	19.88	19.86	N/A	N/A	255.0	231.6	253.7	1
2294	45	1.02	19.79	2	8.5	N/A	19.64	4	19.89	19.88	8.3	N/A	255.0	236.4	253.7	0.9
2299	45	1.00	19.92	2	N/A	N/A	19.85	4	20.56	20.55	N/A	N/A	12956.7	12293.9	12885.8	0.4
2300	45	1.01	19.81	2	8.6	N/A	19.85	4	20.37	20.36	8.3	N/A	12956.7	12282.4	12885.8	0.4
CO_2 atmosphere, J-13 groundwater, Wet-sieved (75-500 µm), Temperature range: 18–25°C, Data binder: TWS-INC-10-93-06 Sample IDs: J-13 Gu3-1407-C.XXXX-25																
2255	43	1.02	19.78	3	7.0	N/A	19.29	3	20.29	20.31	6.7	N/A	247.5	210.7	248.7	2
2256	43	1.03	19.81	3	N/A	N/A	19.30	3	20.22	20.24	N/A	N/A	247.5	222.8	248.7	0.6
2265	43	1.00	19.34	3	7.1	N/A	19.88	3	21.17	21.18	6.9	N/A	11024.1	10331.4	10983.7	0.03
2266	43	1.02	19.42	3	N/A	N/A	19.92	3	20.77	20.77	N/A	N/A	11024.1	10334.2	10983.7	0.06
Air atmosphere, UE-25 p#1 groundwater, Wet-sieved (75-500 µm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: P-1 GU3-1407-C.XXXX-20																
521	11	1.00	19.91	3	8.9	131	20.04	2	20.85	20.85	8.9	159	1851.1	1739.6	1823.5	0.5
522	11	1.00	19.88	3	N/A	N/A	20.11	2	20.90	20.89	N/A	N/A	1851.1	1678.3	1823.5	1
595	12	1.00	19.95	3	8.8	167	20.06	3	20.88	20.88	8.9	176	1748.7	1688.3	1752.0	−0.1
596	12	1.01	19.89	3	N/A	N/A	20.06	3	20.89	20.88	N/A	N/A	1748.7	1650.5	1752.0	0.2
Same as previous heading except: Sample IDs: P-1 GU3-1407-C.XXXX																
715	13	1.00	20.05	2	8.9	197	20.12	3	21.15	21.12	8.9	184	1702.9	1611.1	1755.0	0.1
716	13	1.01	20.03	2	N/A	N/A	20.10	3	21.01	21.01	N/A	N/A	1702.9	1614.7	1755.0	−0.02
729	13	1.00	20.04	2	8.9	185	20.07	5	21.09	21.07	8.9	176	1702.9	1640.5	1755.0	−0.2
730	13	1.03	20.07	2	N/A	N/A	20.04	5	20.76	20.75	N/A	N/A	1702.9	1608.7	1755.0	−0.1
743	13	1.01	20.03	2	9.0	200	19.89	7	20.80	20.77	9.1	235	1702.9	1633.3	1755.0	−0.2
744	13	1.02	20.00	2	N/A	N/A	19.83	7	20.51	20.48	N/A	N/A	1702.9	1612.2	1755.0	0.05
757	13	1.03	20.02	2	8.8	158	20.11	14	20.58	20.46	9.0	184	1702.9	1631.3	1766.2	−0.07
758	13	1.03	20.06	2	N/A	N/A	20.04	14	20.44	20.38	N/A	N/A	1702.9	1631.6	1766.2	−0.07
771	13	1.02	20.10	2	8.9	157	19.98	21	20.50	20.41	9.0	148	1702.9	1652.4	1766.2	−0.2
772	13	1.02	20.06	2	N/A	N/A	19.75	21	20.31	20.21	N/A	N/A	1702.9	1649.9	1766.2	−0.2
785	13	1.00	19.99	2	8.9	170	19.70	31	20.63	20.41	9.0	181	1702.9	1642.1	1766.2	0.01
786	13	1.00	20.09	2	N/A	N/A	19.79	31	20.70	20.52	N/A	N/A	1702.9	1641.6	1766.2	0.002

APPENDIX B: NEPTUNIUM BATCH SORPTION EXPERIMENTAL DATA AND RESULTS

XXXX part of sample ID	Np sorp/ desorp Expt. #	Mass of mineral (g)	Groundwater Pretreatment				Neptunium-237 Solution Sorption Treatment									Distr. Coeff., K_d (mL/g)
			Mass of added water (g)	Period (days)	Final pH	Final Eh	Mass of added soln (g)	Period (days)	Soln/solid ratio (mL/g of solid) Initial	Soln/solid ratio (mL/g of solid) Final	Final pH	Final Eh	Alpha activity in soln (cpm/g of soln) Initial	Alpha activity in soln (cpm/g of soln) Final	Alpha activity in soln (cpm/g of soln) Control	
Tuff USW GU3-1407, Vitric (continued)																
Air atmosphere, UE-25 p#1 groundwater, Wet-sieved (75-500 µm), Temperature range: 22–25°C, Data binder: LA-CST-03-94-09 Sample IDs: P-1-GU3 1407C.XXXX-25																
2305	45	1.00	19.71	2	N/A	N/A	19.82	4	20.60	20.59	N/A	N/A	264.6	244.4	263.0	0.9
2306	45	1.00	19.78	2	9.0	N/A	19.79	4	20.59	20.57	8.8	N/A	264.6	245.4	263.0	0.8
2311	45	1.00	19.86	2	N/A	N/A	19.79	4	20.42	20.40	N/A	N/A	1813.3	1719.9	1813.6	0.5
2312	45	1.01	19.83	2	9.0	N/A	19.68	4	20.29	20.27	8.9	N/A	1813.3	1709.7	1813.6	0.4
CO_2 atmosphere, UE-25 p#1 groundwater, Wet-sieved (75-500 µm), Temperature range: 19–20°C, Data binder: LA-CST-03-94-09 Sample IDs: P-1 Gu3-1407-C.XXXX-25																
2275	44	1.03	19.34	2	7.0	N/A	19.23	4	19.91	19.91	7.0	N/A	250.5	229.7	253.1	0.4
2276	44	1.01	19.31	2	N/A	N/A	20.05	4	20.72	20.72	N/A	N/A	250.5	230.8	253.1	0.8
2285	44	1.01	16.17	2	7.0	N/A	19.73	4	20.47	20.46	6.9	N/A	1757.3	1665.8	1790.7	0.2
2286	44	0.97	19.13	2	N/A	N/A	19.61	4	21.55	21.56	N/A	N/A	1757.3	1663.9	1790.7	−0.2
Tuff USW GU3-1555																
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 µm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: J-13 GU3-1555-C.XXXX-20																
493	11	1.00	19.88	2	8.4	141	19.95	2	20.81	20.75	8.5	197	11304.8	10397.1	11075.1	0.9
494	11	1.00	19.98	2	N/A	N/A	21.05	2	21.89	21.84	N/A	N/A	11304.8	10498.3	11075.1	0.8
553	12	1.04	20.12	2	8.5	197	19.91	3	19.96	19.96	8.4	195	11256.1	10418.7	11333.6	0.7
554	12	1.01	20.11	2	N/A	N/A	19.92	3	20.49	20.48	N/A	N/A	11256.1	10422.0	11333.6	0.8
Same as previous heading except: Data binder: TWS-INC-10-93-06																
2016	20	1.01	19.77	2	8.4	205	19.79	3	20.23	20.23	8.4	216	291.0	251.8	290.2	2
2017	20	1.01	19.86	2	N/A	N/A	19.81	3	20.22	20.22	N/A	N/A	291.0	257.1	290.2	2
Air atmosphere, UE-25 p#1 groundwater, Wet-sieved (75-500 µm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: P-1 GU3-1555-C.XXXX-20																
523	11	1.00	20.02	3	8.8	133	20.07	2	20.91	20.90	8.8	156	1851.1	1651.5	1823.5	2
524	11	1.00	19.99	3	N/A	N/A	20.02	2	20.80	20.78	N/A	N/A	1851.1	1648.4	1823.5	2
597	12	1.00	19.81	3	8.7	182	20.01	3	21.11	21.13	8.9	172	1748.7	1617.8	1752.0	0.5
598	12	1.02	19.83	3	N/A	N/A	20.03	3	20.30	20.31	N/A	N/A	1748.7	1641.9	1752.0	0.6

APPENDIX B: NEPTUNIUM BATCH SORPTION EXPERIMENTAL DATA AND RESULTS

XXXX part of sample ID	Np sorp/ desorp Expt. #	Mass of mineral (g)	Groundwater Pretreatment				Neptunium-237 Solution Sorption Treatment									Distr. Coeff., K_d (mL/g)
			Mass of added water (g)	Period (days)	Final pH	Final Eh	Mass of added soln (g)	Period (days)	Soln/solid ratio (mL/g of solid) Initial	Soln/solid ratio (mL/g of solid) Final	Final pH	Final Eh	Alpha activity in soln (cpm/g of soln) Initial	Alpha activity in soln (cpm/g of soln) Final	Alpha activity in soln (cpm/g of soln) Control	
Tuff USW GU3-1992																
CO_2 atmosphere, J-13 groundwater, Wet-sieved (75-500 µm), Temperature range: 18–20°C, Data binder: LA-CST-03-94-09 Sample IDs: J-13-Gu3 1992-C.XXXX-25																
2317	46	1.00	19.35	2	N/A	N/A	19.45	4	20.85	20.76	6.9	N/A	238.1	171.4	239.2	6
2318	46	0.96	19.34	2	N/A	N/A	19.40	4	21.45	21.35	N/A	N/A	238.1	178.4	239.2	6
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 µm), Temperature range: 22–25°C, Data binder: LA-CST-03-94-09 Sample IDs: J-13 Gu3-1992C.XXXX-25																
2371	47	1.01	19.81	2	N/A	N/A	19.77	5	20.36	20.34	N/A	N/A	266.0	202.6	266.9	5
2371	47	1.01	19.81	2	8.5	N/A	19.78	5	20.44	20.41	8.3	N/A	266.0	207.1	266.9	5
Tuff USW GU3-2325																
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 µm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: J-13 GU3-2325-C.XXXX-20																
495	11	1.00	19.93	2	8.5	146	20.07	2	20.83	20.72	8.5	202	11304.8	10816.3	11075.1	0.3
496	11	1.00	19.96	2	N/A	N/A	20.10	2	21.00	20.93	N/A	N/A	11304.8	10724.0	11075.1	0.3
555	12	1.03	20.02	2	9.1	185	19.98	3	20.19	20.18	8.3	199	11256.1	10755.7	11333.6	0.1
556	12	1.02	19.91	2	N/A	N/A	19.95	3	20.57	20.56	N/A	N/A	11256.1	10603.8	11333.6	0.2
Same as previous heading except: Data binder: TWS-INC-10-93-06																
2018	20	1.01	19.91	2	8.4	202	19.73	3	20.15	20.14	8.4	209	291.0	265.5	290.2	1
2019	20	1.00	19.89	2	N/A	N/A	19.73	3	20.30	20.29	N/A	N/A	291.0	256.5	290.2	2
Air atmosphere, UE-25 p#1 groundwater, Wet-sieved (75-500 µm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: P-1 GU3-2325-C.XXXX-20																
525	11	1.00	19.95	3	9.0	134	20.09	2	20.76	20.75	8.9	149	1851.1	1730.1	1823.5	0.7
526	11	1.00	19.93	3	N/A	N/A	20.01	2	20.71	20.71	N/A	N/A	1851.1	1739.9	1823.5	0.6
599	12	1.04	19.82	3	8.9	177	20.14	3	20.21	20.22	8.9	163	1748.7	1681.1	1752.0	−0.07
600	12	1.01	19.87	3	N/A	N/A	20.12	3	20.71	20.70	N/A	N/A	1748.7	1691.0	1752.0	−0.1

APPENDIX B: NEPTUNIUM BATCH SORPTION EXPERIMENTAL DATA AND RESULTS

XXXX part of sample ID	Np sorp/ desorp Expt. #	Mass of mineral (g)	Groundwater Pretreatment				Neptunium-237 Solution Sorption Treatment									Distr. Coeff., K_d (mL/g)
			Mass of added water (g)	Period (days)	Final pH	Final Eh	Mass of added soln (g)	Period (days)	Soln/solid ratio (mL/g of solid) Initial	Soln/solid ratio (mL/g of solid) Final	Final pH	Final Eh	Alpha activity in soln (cpm/g of soln) Initial	Alpha activity in soln (cpm/g of soln) Final	Alpha activity in soln (cpm/g of soln) Control	
Synthetic Calcite																
Air atmosphere, J-13 groundwater, Not sieved, Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01																
Sample IDs: J-13-A-C.XXXX-20																
1	1	1.00	20.02	15	8.1	260	20.12	21	20.85	20.75	8.6	254	252.8	66.9	258.7	60
2	1	1.00	20.02	15	N/A	N/A	20.23	21	21.36	21.22	N/A	N/A	252.8	67.9	258.7	50
157	3	1.01	20.02	14	8.4	238	20.11	21	20.61	20.43	8.5	226	474.5	183.5	473.6	30
158	3	1.00	20.03	14	N/A	N/A	20.14	21	21.04	20.85	N/A	N/A	474.5	167.2	473.6	40
329	6	1.02	19.87	2	8.4	255	20.04	4	20.29	20.20	8.3	243	444.9	189.7	438.6	30
330	6	1.01	19.39	2	N/A	N/A	20.04	4	20.48	20.38	N/A	N/A	444.9	194.0	438.6	30
383	8	1.00	19.98	5	8.4	200	20.01	2	20.47	20.36	8.5	223	12860.1	12063.3	13219.2	1
384	8	1.01	20.02	5	N/A	N/A	19.97	2	20.20	20.26	N/A	N/A	12860.1	12317.1	13219.2	0.4
573	12	1.09	20.04	2	8.4	228	20.07	3	19.21	19.19	8.3	204	11256.1	9990.0	11333.6	2
574	12	1.04	19.99	2	N/A	N/A	20.04	3	19.85	19.84	N/A	N/A	11256.1	10027.0	11333.6	2
Air atmosphere, UE-25 p#1 groundwater, Not sieved, Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01																
Sample IDs: P-1-A-C.XXXX-20																
79	2	1.02	20.14	14	8.8	240	20.19	21	20.34	20.20	8.9	231	220.4	61.9	218.8	50
235	4	1.01	20.15	13	9.3	214	20.09	21	20.60	20.42	8.8	239	480.9	343.1	512.5	7
236	4	1.02	20.03	13	N/A	N/A	20.23	21	20.64	20.52	N/A	N/A	480.9	238.4	512.5	20
347	6	1.00	19.97	2	8.9	222	20.24	4	21.04	20.92	8.7	246	478.8	277.3	514.6	10
348	6	1.01	20.13	2	N/A	N/A	20.12	4	20.58	20.51	N/A	N/A	478.8	270.3	514.6	10
365	7	1.00	20.05	4	9.2	190	20.10	2	20.81	20.76	8.6	193	2234.8	1826.7	2290.4	4
366	7	1.00	20.03	4	N/A	N/A	19.99	2	20.73	20.73	N/A	N/A	2234.8	1862.3	2290.4	3
443	9	1.00	19.78	2	8.8	185	20.29	2	21.34	21.16	8.9	184	2536.0	2023.4	2559.0	4
444	9	1.00	19.78	2	N/A	N/A	20.14	2	20.72	20.61	N/A	N/A	2536.0	2056.7	2559.0	4
617	12	1.05	20.00	3	8.8	179	20.01	3	19.99	19.98	8.9	179	1748.7	1292.6	1752.0	6
618	12	1.01	19.99	3	N/A	N/A	20.02	3	21.34	21.33	N/A	N/A	1748.7	1283.4	1752.0	6

APPENDIX B: NEPTUNIUM BATCH SORPTION EXPERIMENTAL DATA AND RESULTS

XXXX part of sample ID	Np sorp/ desorp Expt. #	Mass of mineral (g)	Groundwater Pretreatment				Neptunium-237 Solution Sorption Treatment									Distr. Coeff., K_d (mL/g)
			Mass of added water (g)	Period (days)	Final pH	Final Eh	Mass of added soln (g)	Period (days)	Soln/solid ratio (mL/g of solid)		Final pH	Final Eh	Alpha activity in soln (cpm/g of soln)			
									Initial	Final			Initial	Final	Control	
Natural Calcite																
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01																
Sample IDs: J-13-B-C.XXXX-20																
55	1	1.01	20.06	14	8.5	295	20.29	17	20.53	20.10	8.5	243	255.1	43.6	258.8	100
211	3	1.00	20.13	15	8.3	234	19.34	22	20.14	19.91	8.3	254	462.7	120.1	476.4	50
212	3	1.04	20.10	15	N/A	N/A	19.94	22	19.85	19.67	N/A	N/A	462.7	116.7	476.4	60
385	8	1.00	19.98	5	8.5	190	20.01	2	20.49	20.46	8.6	233	12860.1	11546.2	13219.2	2
386	8	1.00	19.83	5	N/A	N/A	19.99	2	20.44	20.49	N/A	N/A	12860.1	11886.2	13219.2	1
575	12	1.02	20.16	2	8.4	219	20.11	3	20.35	20.34	8.6	205	11256.1	9778.3	11333.6	2
576	12	1.04	20.01	2	N/A	N/A	20.10	3	19.92	19.91	N/A	N/A	11256.1	9144.2	11333.6	4
Same as previous heading except: Sample IDs: J-13 B-C.XXXX																
633	13	1.03	20.01	2	8.4	208	19.69	3	19.81	19.81	8.5	195	8276.5	6980.7	8600.6	3
634	13	1.00	20.01	2	N/A	N/A	19.69	3	20.25	20.24	N/A	N/A	8276.5	7043.8	8600.6	3
647	13	1.03	20.02	2	8.5	206	19.70	5	19.65	19.62	8.6	201	8276.5	6954.8	8600.6	3
648	13	1.00	20.09	2	N/A	N/A	19.65	5	20.40	20.37	N/A	N/A	8276.5	6993.1	8600.6	3
661	13	1.01	19.98	2	8.4	216	19.75	7	20.21	20.17	8.4	206	8276.5	6393.0	8600.6	5
662	13	1.03	20.02	2	N/A	N/A	19.71	7	19.81	19.76	N/A	N/A	8276.5	6208.8	8600.6	6
675	13	1.01	19.96	2	8.4	236	19.48	14	19.96	19.91	8.7	212	8276.5	4790.0	8620.3	10
676	13	1.03	19.93	2	N/A	N/A	19.43	14	19.41	19.35	N/A	N/A	8276.5	4651.1	8620.3	10
689	13	1.01	19.98	2	8.4	270	19.64	21	20.04	19.93	8.7	152	8276.5	4183.8	8620.3	20
690	13	1.02	19.99	2	N/A	N/A	19.66	21	19.92	19.78	N/A	N/A	8276.5	4379.0	8620.3	20
703	13	1.03	20.03	2	8.3	234	19.66	31	19.76	19.57	8.6	152	8276.5	3506.5	8620.3	30
704	13	1.01	20.07	2	N/A	N/A	19.69	31	20.10	19.93	N/A	N/A	8276.5	3828.0	8620.3	20
Same as previous complete heading except: Dry-sieved (75-500 μm)																
3	1	1.00	19.99	15	8.2	276	20.23	21	20.94	20.73	8.5	257	252.8	5.1	258.7	1000
4	1	1.00	20.03	15	N/A	N/A	20.20	21	21.11	20.96	N/A	N/A	252.8	5.6	258.7	900
159	3	1.04	20.04	14	8.3	240	20.16	21	20.14	20.00	8.4	248	474.5	13.9	473.6	600
160	3	0.99	19.97	14	N/A	N/A	20.14	21	21.27	21.13	N/A	N/A	474.5	17.1	473.6	500
331	6	1.01	19.98	2	8.4	266	19.91	4	20.21	20.15	8.3	275	444.9	123.7	438.6	50
332	6	1.00	19.92	2	N/A	N/A	19.97	4	20.41	20.38	N/A	N/A	444.9	122.2	438.6	50

APPENDIX B: NEPTUNIUM BATCH SORPTION EXPERIMENTAL DATA AND RESULTS

XXXX part of sample ID	Np sorp/ desorp Expt. #	Mass of mineral (g)	Groundwater Pretreatment				Neptunium-237 Solution Sorption Treatment									Distr. Coeff., K_d (mL/g)
			Mass of added water (g)	Period (days)	Final pH	Final Eh	Mass of added soln (g)	Period (days)	Soln/solid ratio (mL/g of solid) Initial	Soln/solid ratio (mL/g of solid) Final	Final pH	Final Eh	Alpha activity in soln (cpm/g of soln) Initial	Alpha activity in soln (cpm/g of soln) Final	Alpha activity in soln (cpm/g of soln) Control	
Natural Calcite (continued)																
Air atmosphere, UE-25 p#1 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01																
Sample IDs: P-1-B-C.XXXX-20																
133	2	1.04	20.00	14	8.9	207	20.15	24	20.01	19.72	8.9	196	217.4	5.7	222.3	700
289	4	1.00	20.07	13	8.9	198	20.21	21	21.13	20.97	8.9	218	515.4	26.5	528.1	400
290	4	1.03	20.10	13	N/A	N/A	20.25	21	20.45	20.31	N/A	N/A	515.4	32.4	528.1	300
367	7	1.00	20.05	4	8.8	167	20.17	2	20.78	20.75	8.7	205	2234.8	1219.8	2290.4	20
368	7	1.00	20.14	4	N/A	N/A	20.06	2	20.76	20.75	N/A	N/A	2234.8	1198.2	2290.4	20
619	12	1.01	19.93	3	8.8	176	20.13	3	20.91	20.92	9.0	162	1748.7	956.5	1752.0	20
620	12	1.03	19.97	3	N/A	N/A	20.08	3	20.47	20.46	N/A	N/A	1748.7	740.5	1752.0	30
Same as previous heading except: Sample IDs: P-1 B-C.XXXX																
717	13	1.03	20.03	2	8.9	196	20.05	3	20.00	19.99	8.9	183	1702.9	785.7	1755.0	20
718	13	1.02	19.99	2	N/A	N/A	20.07	3	20.27	20.26	N/A	N/A	1702.9	752.1	1755.0	20
731	13	1.02	20.12	2	9.0	180	20.01	5	20.24	20.18	9.1	171	1702.9	557.0	1755.0	40
732	13	1.03	20.10	2	N/A	N/A	19.96	5	20.13	20.09	N/A	N/A	1702.9	560.4	1755.0	40
745	13	1.02	20.09	2	9.0	197	19.78	7	20.06	20.02	9.2	204	1702.9	462.6	1755.0	50
746	13	1.01	20.06	2	N/A	N/A	19.19	7	19.68	19.65	N/A	N/A	1702.9	366.5	1755.0	70
759	13	1.02	20.06	2	8.8	155	20.06	14	20.36	20.03	9.0	186	1702.9	225.4	1766.2	100
760	13	1.02	20.06	2	N/A	N/A	20.01	14	20.45	20.38	N/A	N/A	1702.9	199.5	1766.2	100
773	13	1.01	20.23	2	8.9	162	19.97	21	20.38	20.29	9.0	159	1702.9	78.9	1766.2	400
774	13	1.03	20.21	2	N/A	N/A	20.01	21	20.13	20.03	N/A	N/A	1702.9	89.0	1766.2	400
787	13	1.01	20.04	2	8.9	167	19.80	31	20.19	20.02	9.0	168	1702.9	39.6	1766.2	800
788	13	1.02	20.09	2	N/A	N/A	19.88	31	20.20	20.04	N/A	N/A	1702.9	29.1	1766.2	1000
Same as previous complete heading except: Dry-sieved (75-500 μm)																
81	2	1.02	20.01	14	9.0	231	20.19	21	20.46	20.32	8.9	239	220.4	2.1	218.8	2000
82	2	1.01	20.01	14	N/A	N/A	20.12	21	20.66	20.45	N/A	N/A	220.4	1.5	218.8	3000
237	4	1.03	20.00	13	8.6	219	20.21	21	21.17	21.04	9.0	240	480.9	245.2	512.5	20
238	4	1.01	20.00	13	N/A	N/A	20.25	21	21.31	21.18	N/A	N/A	480.9	3.4	512.5	3000
349	6	1.01	19.96	2	8.9	256	20.03	4	20.43	20.46	N/A	182	478.8	83.9	514.6	90
350	6	1.02	19.97	2	N/A	N/A	20.02	4	20.32	20.33	N/A	N/A	478.8	88.0	514.6	90

APPENDIX B: NEPTUNIUM BATCH SORPTION EXPERIMENTAL DATA AND RESULTS

XXXX part of sample ID	Np sorp/ desorp Expt. #	Mass of mineral (g)	Groundwater Pretreatment				Neptunium-237 Solution Sorption Treatment									Distr. Coeff., K_d (mL/g)
			Mass of added water (g)	Period (days)	Final pH	Final Eh	Mass of added soln (g)	Period (days)	Soln/solid ratio (mL/g of solid)		Final pH	Final Eh	Alpha activity in soln (cpm/g of soln)			
									Initial	Final			Initial	Final	Control	
Synthetic Hematite																
Air atmosphere, J-13 groundwater, Not sieved, Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01																
Sample IDs: J-13-C-C.XXXX-20																
5	1	1.00	20.00	15	8.3	260	20.21	21	20.77	20.64	8.5	264	252.8	3.2	258.7	2000
6	1	1.01	19.98	15	N/A	N/A	20.19	21	20.86	20.75	N/A	N/A	252.8	2.6	258.7	2000
161	3	1.00	20.16	14	8.2	244	20.13	21	20.81	20.59	8.4	234	474.5	4.7	473.6	2000
162	3	1.01	20.13	14	N/A	N/A	20.16	21	20.82	20.50	N/A	N/A	474.5	5.4	473.6	2000
333	6	1.00	21.04	2	8.5	226	19.94	4	20.52	20.45	8.2	213	444.9	52.8	438.6	100
334	6	1.02	19.99	2	N/A	N/A	19.95	4	20.15	20.07	N/A	N/A	444.9	15.0	438.6	600
387	8	1.00	19.89	5	8.1	249	19.97	2	20.59	20.64	8.5	275	12860.1	1038.7	13219.2	200
388	8	1.00	19.86	5	N/A	N/A	20.01	2	20.48	20.49	N/A	N/A	12860.1	1204.2	13219.2	200
433	9	1.00	19.80	2	7.7	198	20.09	2	20.67	20.58	8.6	200	14779.0	3358.9	14778.3	70
434	9	1.00	19.76	2	N/A	N/A	20.13	2	20.73	20.59	N/A	N/A	14779.0	3118.3	14778.3	70
577	12	1.05	20.19	2	7.8	232	20.09	3	19.70	19.70	8.3	215	11256.1	286.2	11333.6	700
578	12	1.03	20.60	2	N/A	N/A	20.10	3	20.10	20.09	N/A	N/A	11256.1	392.8	11333.6	500
Same as previous heading except: Sample IDs: J-13 C-C.XXXX																
635	13	1.03	20.02	2	7.7	221	19.68	3	19.77	19.68	8.3	201	8276.5	1267.4	8600.6	100
636	13	1.02	20.11	2	N/A	N/A	19.69	3	19.99	19.96	N/A	N/A	8276.5	1243.6	8600.6	100
649	13	1.01	19.85	2	7.6	224	19.66	5	20.03	19.96	8.2	219	8276.5	879.9	8600.6	200
650	13	1.03	19.87	2	N/A	N/A	19.63	5	19.73	19.68	N/A	N/A	8276.5	861.7	8600.6	200
663	13	1.03	19.91	2	7.8	231	19.70	7	19.60	19.57	8.8	231	8276.5	641.3	8600.6	200
664	13	1.02	19.93	2	N/A	N/A	19.70	7	20.00	19.96	N/A	N/A	8276.5	637.7	8600.6	200
677	13	1.03	19.94	2	7.6	237	19.51	14	19.55	19.44	8.5	206	8276.5	154.0	8620.3	1000
678	13	1.00	19.98	2	N/A	N/A	19.57	14	20.03	19.96	N/A	N/A	8276.5	154.0	8620.3	1000
691	13	1.01	20.18	2	7.7	243	19.62	21	20.37	20.13	8.5	138	8276.5	220.1	8620.3	700
692	13	1.02	20.01	2	N/A	N/A	19.60	21	19.81	19.35	N/A	N/A	8276.5	142.0	8620.3	1000
705	13	1.01	20.04	2	7.5	242	19.24	31	19.54	19.16	8.5	161	8276.5	121.7	8620.3	1000
706	13	1.02	20.08	2	N/A	N/A	19.62	31	19.84	19.61	N/A	N/A	8276.5	111.8	8620.3	1000
CO_2 atmosphere, J-13 groundwater, Not sieved, Temperature range: 18–25°C, Data binder: TWS-INC-10-93-06																
Sample IDs: C-C.XXXX-25																
2257	43	1.03	19.76	3	6.8	N/A	19.25	3	20.22	20.23	6.6	N/A	247.5	17.4	248.7	200
2258	43	0.98	19.49	3	N/A	N/A	17.99	3	20.55	20.57	N/A	N/A	247.5	8.5	248.7	500
2267	43	0.98	19.52	3	6.8	N/A	19.84	3	21.21	21.22	6.9	N/A	11024.1	2401.5	10983.7	70
2268	43	1.01	19.66	3	N/A	N/A	19.77	3	20.67	20.67	N/A	N/A	11024.1	2271.6	10983.7	70

APPENDIX B: NEPTUNIUM BATCH SORPTION EXPERIMENTAL DATA AND RESULTS

XXXX part of sample ID	Np sorp/ desorp Expt. #	Mass of mineral (g)	Groundwater Pretreatment				Neptunium-237 Solution Sorption Treatment									Distr. Coeff., K_d (mL/g)
			Mass of added water (g)	Period (days)	Final pH	Final Eh	Mass of added soln (g)	Period (days)	Soln/solid ratio (mL/g of solid)		Final pH	Final Eh	Alpha activity in soln (cpm/g of soln)			
									Initial	Final			Initial	Final	Control	
Synthetic Hematite (continued)																
Air atmosphere, UE-25 p#1 groundwater, Not sieved, Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01																
Sample IDs: P-1-C-C.XXXX-20																
83	2	1.00	19.91	14	8.6	246	20.14	21	20.73	20.55	8.9	219	220.4	1.6	218.8	3000
84	2	1.00	20.01	14	N/A	N/A	20.13	21	21.31	21.16	N/A	N/A	220.4	2.2	218.8	2000
239	4	1.00	19.96	13	8.5	221	20.17	21	21.00	20.86	9.2	238	480.9	3.6	512.5	3000
240	4	1.03	19.94	13	N/A	N/A	20.29	21	20.63	20.48	N/A	N/A	480.9	3.4	512.5	3000
351	6	1.03	19.92	2	8.6	254	20.01	4	20.04	20.06	8.6	194	478.8	12.7	514.6	700
352	6	1.02	20.06	2	N/A	N/A	19.93	4	20.07	20.07	N/A	N/A	478.8	12.0	514.6	800
369	7	1.00	20.11	4	8.5	225	20.10	2	20.76	20.71	8.7	192	2234.8	78.6	2290.4	600
370	7	1.00	20.10	4	N/A	N/A	20.00	2	20.54	20.57	N/A	N/A	2234.8	71.4	2290.4	600
621	12	1.01	19.92	3	8.2	188	20.41	3	20.96	20.96	8.6	164	1748.7	41.7	1752.0	800
622	12	1.02	19.90	3	N/A	N/A	20.16	3	20.97	20.97	N/A	N/A	1748.7	42.2	1752.0	800
Same as previous heading except: Sample IDs: P-1 C-C.XXXX																
719	13	1.01	20.02	2	8.3	204	20.00	3	20.48	20.47	8.5	190	1702.9	37.3	1755.0	900
720	13	1.00	20.03	2	N/A	N/A	20.08	3	20.74	20.73	N/A	N/A	1702.9	139.1	1755.0	200
733	13	1.02	19.96	2	8.3	199	19.95	5	20.15	20.12	8.7	176	1702.9	21.9	1755.0	1000
734	13	1.00	20.08	2	N/A	N/A	20.00	5	20.62	20.60	N/A	N/A	1702.9	20.7	1755.0	2000
747	13	1.03	20.05	2	8.3	209	19.88	7	20.07	20.03	8.8	201	1702.9	20.0	1755.0	2000
748	13	1.02	20.09	2	N/A	N/A	19.87	7	20.14	20.10	N/A	N/A	1702.9	85.4	1755.0	400
761	13	1.02	20.04	2	8.3	190	20.01	14	20.15	20.09	8.8	194	1702.9	14.8	1766.2	2000
762	13	1.02	20.07	2	N/A	N/A	20.08	14	20.26	20.19	N/A	N/A	1702.9	15.2	1766.2	2000
775	13	1.01	20.22	2	8.4	182	20.03	21	20.42	20.23	8.8	148	1702.9	13.7	1766.2	2000
776	13	1.03	20.18	2	N/A	N/A	19.69	21	19.80	19.67	N/A	N/A	1702.9	12.9	1766.2	2000
789	13	1.01	20.10	2	8.4	180	19.77	31	20.32	19.91	8.8	157	1702.9	12.6	1766.2	3000
790	13	1.02	20.13	2	N/A	N/A	19.90	31	20.14	19.94	N/A	N/A	1702.9	12.7	1766.2	3000
CO_2 atmosphere, UE-25 p#1 groundwater, Not sieved, Temperature range: 19–20°C, Data binder: LA-CST-03-94-09																
Sample IDs: C-C.XXXX-25																
2277	44	0.99	19.12	2	6.9	N/A	19.77	4	20.94	20.93	7.1	N/A	250.5	4.5	253.1	1000
2278	44	1.00	19.14	2	N/A	N/A	19.80	4	20.99	20.99	N/A	N/A	250.5	4.7	253.1	1000
2287	44	1.00	17.00	2	7.0	N/A	19.61	4	20.84	20.81	7.0	N/A	1757.3	84.4	1790.7	400
2288	44	0.99	17.05	2	N/A	N/A	19.85	4	20.98	20.97	N/A	N/A	1757.3	187.9	1790.7	200

APPENDIX B: NEPTUNIUM BATCH SORPTION EXPERIMENTAL DATA AND RESULTS

XXXX part of sample ID	Np sorp/ desorp Expt. #	Mass of mineral (g)	Groundwater Pretreatment				Neptunium-237 Solution Sorption Treatment									Distr. Coeff., K_d (mL/g)
			Mass of added water (g)	Period (days)	Final pH	Final Eh	Mass of added soln (g)	Period (days)	Soln/solid ratio (mL/g of solid)		Final pH	Final Eh	Alpha activity in soln (cpm/g of soln)			
									Initial	Final			Initial	Final	Control	
Clinoptilolite																
Air atmosphere, J-13 groundwater, Not sieved, Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: J-13-G-C.XXXX-20																
9	1	1.00	20.02	15	8.5	310	20.07	21	20.99	20.83	8.6	267	252.8	217.2	258.7	3
10	1	1.01	20.00	15	N/A	N/A	20.15	21	20.90	20.65	N/A	N/A	252.8	213.9	258.7	3
165	3	1.03	20.06	14	8.7	239	20.06	21	21.38	21.16	8.5	234	474.5	370.9	473.6	4
166	3	1.00	20.01	14	N/A	N/A	19.97	21	21.42	21.16	N/A	N/A	474.5	383.5	473.6	4
337	6	1.02	19.94	2	8.5	307	19.86	4	20.68	20.61	8.3	209	444.9	368.6	438.6	3
338	6	1.00	20.91	2	N/A	N/A	20.01	4	21.09	20.93	N/A	N/A	444.9	370.8	438.6	3
391	8	1.00	19.90	5	8.4	184	20.03	2	21.37	21.32	8.6	240	12860.1	11633.8	13219.2	0.8
392	8	1.00	19.91	5	N/A	N/A	20.04	2	21.00	21.10	N/A	N/A	12860.1	11961.7	13219.2	0.4
581	12	1.02	20.84	2	8.6	204	20.09	3	20.65	20.64	8.4	208	11256.1	10122.3	11333.6	1
582	12	1.02	19.97	2	N/A	N/A	20.04	3	20.68	20.67	N/A	N/A	11256.1	10017.3	11333.6	1
Same as previous heading except: Sample IDs: J-13 G-C.XXXX																
637	13	1.00	19.95	2	8.5	210	19.74	3	20.77	20.55	8.3	194	8276.5	7360.1	8600.6	2
638	13	1.00	20.07	2	N/A	N/A	19.69	3	20.78	20.77	N/A	N/A	8276.5	7391.9	8600.6	1
651	13	1.01	19.94	2	8.5	279	19.84	5	20.63	20.55	8.4	196	8276.5	7646.5	8600.6	0.7
652	13	1.02	19.93	2	N/A	N/A	19.52	5	20.18	20.13	N/A	N/A	8276.5	7581.9	8600.6	0.8
665	13	1.00	19.96	2	8.4	219	19.68	7	20.80	20.74	8.6	211	8276.5	7670.1	8600.6	0.5
666	13	1.00	19.96	2	N/A	N/A	19.70	7	20.78	20.71	N/A	N/A	8276.5	7590.5	8600.6	0.8
679	13	1.01	19.99	2	8.4	279	19.56	14	20.36	20.27	8.5	195	8276.5	7622.8	8620.3	0.8
680	13	1.03	20.00	2	N/A	N/A	19.61	14	20.13	20.07	N/A	N/A	8276.5	7493.0	8620.3	1
693	13	1.00	19.97	2	8.4	222	19.62	21	20.46	20.34	8.7	151	8276.5	7687.8	8620.3	0.8
694	13	1.01	20.07	2	N/A	N/A	19.61	21	20.47	20.36	N/A	N/A	8276.5	7559.4	8620.3	0.9
707	13	1.01	20.07	2	8.4	223	19.65	31	20.39	20.16	8.5	175	8276.5	7595.8	8620.3	1
708	13	1.00	20.05	2	N/A	N/A	19.61	31	20.65	20.40	N/A	N/A	8276.5	7584.7	8620.3	1
CO_2 atmosphere, J-13 groundwater, Not sieved, Temperature range: 18–25°C, Data binder: TWS-INC-10-93-06 Sample IDs: G-C.XXXX-25																
2259	43	0.97	19.72	3	7.1	N/A	19.21	3	21.13	21.15	7.0	N/A	247.5	185.9	248.7	5
2260	43	1.03	19.78	3	N/A	N/A	18.76	3	19.42	19.43	N/A	N/A	247.5	184.1	248.7	5
2269	43	1.00	19.30	3	7.2	N/A	19.71	3	20.89	20.90	7.0	N/A	11024.1	9369.6	10983.7	2
2270	43	1.00	19.29	3	N/A	N/A	19.71	3	21.02	21.04	N/A	N/A	11024.1	9256.8	10983.7	2

APPENDIX B: NEPTUNIUM BATCH SORPTION EXPERIMENTAL DATA AND RESULTS

XXXX part of sample ID	Np sorp/ desorp Expt. #	Mass of mineral (g)	Groundwater Pretreatment				Neptunium-237 Solution Sorption Treatment									Distr. Coeff., K_d (mL/g)
			Mass of added water (g)	Period (days)	Final pH	Final Eh	Mass of added soln (g)	Period (days)	Soln/solid ratio (mL/g of solid) Initial	Soln/solid ratio (mL/g of solid) Final	Final pH	Final Eh	Alpha activity in soln (cpm/g of soln) Initial	Alpha activity in soln (cpm/g of soln) Final	Alpha activity in soln (cpm/g of soln) Control	
Clinoptilolite (continued)																
Air atmosphere, UE-25 p#1 groundwater, Not sieved, Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: P-1-G-C.XXXX-20																
87	2	1.00	20.11	14	9.1	225	20.13	21	21.45	21.26	9.0	228	220.4	199.7	218.8	1
88	2	1.00	19.93	14	N/A	N/A	20.05	21	21.44	21.30	N/A	N/A	220.4	196.2	218.8	1
243	4	1.02	20.06	13	8.8	206	20.27	21	21.36	21.30	9.0	222	480.9	452.7	512.5	−0.2
244	4	1.01	19.99	13	N/A	N/A	20.22	21	21.33	21.19	N/A	N/A	480.9	460.8	512.5	−0.3
355	6	1.00	19.98	2	8.9	264	19.97	4	20.91	20.78	8.8	176	478.8	476.1	514.6	−0.7
356	6	1.00	19.98	2	N/A	N/A	20.07	4	21.08	21.00	N/A	N/A	478.8	470.3	514.6	−0.6
373	7	1.00	20.10	4	8.8	158	20.02	2	20.97	20.92	8.9	182	2234.8	2109.8	2290.4	0.3
374	7	1.00	19.99	4	N/A	N/A	19.95	2	21.16	21.16	N/A	N/A	2234.8	2093.0	2290.4	0.1
625	12	1.00	19.94	3	8.8	170	20.21	3	21.54	21.54	9.0	169	1748.7	1626.7	1752.0	0.2
626	12	1.03	19.91	3	N/A	N/A	20.20	3	20.78	20.76	N/A	N/A	1748.7	1629.2	1752.0	0.3
Same as previous heading except: Sample IDs: P-1 G-C.XXXX																
721	13	1.01	21.07	2	8.9	202	20.03	3	20.80	20.79	8.9	179	1702.9	1611.3	1755.0	0.2
722	13	1.02	20.06	2	N/A	N/A	20.05	3	20.70	20.69	N/A	N/A	1702.9	1605.6	1755.0	0.2
735	13	1.01	20.09	2	8.9	179	19.94	5	20.88	20.87	9.0	173	1702.9	1637.6	1755.0	−0.3
736	13	1.00	20.11	2	N/A	N/A	19.97	5	21.00	20.97	N/A	N/A	1702.9	1646.4	1755.0	−0.3
749	13	1.02	20.16	2	8.9	194	19.89	7	20.38	20.25	9.1	184	1702.9	1644.9	1755.0	−0.07
750	13	1.02	20.09	2	N/A	N/A	19.84	7	20.50	20.46	N/A	N/A	1702.9	1618.1	1755.0	0.01
763	13	1.01	20.10	2	8.9	158	19.92	14	20.81	20.70	9.1	181	1702.9	1632.3	1766.2	−0.1
764	13	1.00	20.05	2	N/A	N/A	20.05	14	21.08	21.02	N/A	N/A	1702.9	1618.0	1766.2	0.08
777	13	1.01	20.19	2	8.8	159	20.00	21	20.83	19.82	9.0	138	1702.9	1626.7	1766.2	0.9
778	13	1.02	20.14	2	N/A	N/A	19.97	21	20.55	20.40	N/A	N/A	1702.9	1628.4	1766.2	0.07
791	13	1.00	20.09	2	8.8	166	19.88	31	20.82	20.62	9.0	181	1702.9	1637.1	1766.2	0.06
792	13	1.00	20.10	2	N/A	N/A	19.77	31	20.65	19.96	N/A	N/A	1702.9	1651.1	1766.2	0.4
CO_2 atmosphere, UE-25 p#1 groundwater, Not sieved, Temperature range: 19–20°C, Data binder: LA-CST-03-94-09 Sample IDs: G-C.XXXX-25																
2279	44	1.00	19.04	2	7.1	N/A	19.70	4	20.95	20.95	7.0	N/A	250.5	225.6	253.1	0.9
2280	44	1.00	19.20	2	N/A	N/A	19.73	4	21.34	21.33	N/A	N/A	250.5	224.3	253.1	0.7
2289	44	1.00	19.18	2	7.1	N/A	19.72	4	20.96	20.96	7.1	N/A	1757.3	1608.5	1790.7	0.6
2290	44	0.98	19.21	2	N/A	N/A	19.75	4	21.26	21.26	N/A	N/A	1757.3	1642.5	1790.7	0.3

APPENDIX B: NEPTUNIUM BATCH SORPTION EXPERIMENTAL DATA AND RESULTS

XXXX part of sample ID	Np sorp/ desorp Expt. #	Mass of mineral (g)	Groundwater Pretreatment				Neptunium-237 Solution Sorption Treatment									Distr. Coeff., K_d (mL/g)
			Mass of added water (g)	Period (days)	Final pH	Final Eh	Mass of added soln (g)	Period (days)	Soln/solid ratio (mL/g of solid) Initial	Soln/solid ratio (mL/g of solid) Final	Final pH	Final Eh	Alpha activity in soln (cpm/g of soln) Initial	Alpha activity in soln (cpm/g of soln) Final	Alpha activity in soln (cpm/g of soln) Control	
Quartz																
Air atmosphere, J-13 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01																
Sample IDs: J-13-M-C.XXXX-20																
62	1	1.00	20.00	14	N/A	N/A	20.14	17	20.64	20.48	N/A	N/A	255.1	253.1	258.8	−0.2
217	3	1.00	20.07	15	8.4	216	20.17	22	21.08	20.85	8.4	245	462.7	452.1	476.4	−0.2
218	3	1.05	20.04	15	N/A	N/A	19.99	22	20.18	19.93	N/A	N/A	462.7	445.3	476.4	−0.1
393	8	1.01	19.90	5	8.5	287	19.93	2	20.14	20.15	8.4	189	12860.1	13196.8	13219.2	−0.9
394	8	1.00	19.79	5	N/A	N/A	19.93	2	20.43	20.46	N/A	N/A	12860.1	12756.0	13219.2	−0.4
435	9	1.00	19.76	2	8.6	198	20.15	2	20.80	20.63	8.5	184	14779.0	14297.3	14778.3	0.2
436	9	1.00	19.76	2	N/A	N/A	20.10	2	20.98	20.86	N/A	N/A	14779.0	14056.2	14778.3	0.3
579	12	1.01	20.21	2	8.1	224	20.07	3	20.50	20.49	8.5	208	11256.1	10994.8	11333.6	−0.1
580	12	1.06	20.07	2	N/A	N/A	20.07	3	19.49	19.47	N/A	N/A	11256.1	11025.5	11333.6	−0.1
Same as previous heading except: Dry-sieved (75-500 μm)																
11	1	1.01	20.01	15	8.0	348	20.14	21	20.83	20.62	8.4	265	252.8	247.9	258.7	−0.3
12	1	1.00	20.02	15	N/A	N/A	20.09	21	20.53	20.35	N/A	N/A	252.8	249.1	258.7	0.03
168	3	1.02	19.98	14	N/A	N/A	20.07	21	20.40	20.03	N/A	N/A	474.5	460.3	473.6	0.3
339	6	1.00	19.93	2	8.4	268	19.86	4	20.49	20.44	8.2	210	444.9	428.4	438.6	0.2
340	6	1.00	19.83	2	N/A	N/A	19.84	4	20.47	20.42	N/A	N/A	444.9	426.0	438.6	0.3
Air atmosphere, UE-25 p#1 groundwater, Wet-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01																
Sample IDs: P-1-M-C.XXXX-20																
296	4	1.00	19.99	13	N/A	N/A	20.21	21	20.98	20.67	N/A	N/A	515.4	490.7	528.1	0.6
375	7	1.00	20.09	4	8.9	221	19.94	2	20.64	20.65	10.0	211	2234.8	2222.5	2290.4	−0.6
376	7	1.00	20.09	4	N/A	N/A	20.03	2	20.59	20.54	N/A	N/A	2234.8	2234.5	2290.4	−0.5
447	9	1.00	19.73	2	9.0	176	20.21	2	20.80	20.64	9.0	189	2536.0	2482.1	2559.0	0.01
448	9	1.00	19.75	2	N/A	N/A	20.15	2	20.66	20.50	N/A	N/A	2536.0	2508.1	2559.0	−0.1
623	12	1.00	19.93	3	8.9	179	20.40	3	21.03	21.03	9.0	173	1748.7	1704.7	1752.0	−0.1
624	12	1.03	19.91	3	N/A	N/A	20.22	3	20.50	20.50	N/A	N/A	1748.7	1685.3	1752.0	−0.1
Same as previous heading except: Dry-sieved (75-500 μm)																
89	2	1.02	20.02	14	9.0	227	20.03	21	20.10	19.98	8.9	229	220.4	214.8	218.8	0.2
90	2	1.02	19.98	14	N/A	N/A	20.03	21	20.46	20.33	N/A	N/A	220.4	212.0	218.8	0.08
245	4	1.00	20.10	13	8.8	211	20.24	21	21.29	21.12	9.0	222	480.9	495.6	512.5	−1
246	4	1.00	20.01	13	N/A	N/A	20.24	21	20.99	20.86	N/A	N/A	480.9	501.4	512.5	−1
357	6	1.02	19.98	2	8.9	224	19.95	4	20.19	20.08	8.8	231	478.8	494.3	514.6	−1
358	6	1.01	19.98	2	N/A	N/A	20.07	4	20.32	20.13	N/A	N/A	478.8	495.2	514.6	−0.9

APPENDIX B: NEPTUNIUM BATCH SORPTION EXPERIMENTAL DATA AND RESULTS

XXXX part of sample ID	Np sorp/ desorp Expt. #	Mass of mineral (g)	Groundwater Pretreatment				Neptunium-237 Solution Sorption Treatment									Distr. Coeff., K_d (mL/g)
			Mass of added water (g)	Period (days)	Final pH	Final Eh	Mass of added soln (g)	Period (days)	Soln/solid ratio (mL/g of solid) Initial	Soln/solid ratio (mL/g of solid) Final	Final pH	Final Eh	Alpha activity in soln (cpm/g of soln) Initial	Alpha activity in soln (cpm/g of soln) Final	Alpha activity in soln (cpm/g of soln) Control	
Montmorillonite																
Air atmosphere, J-13 groundwater, Dry-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: J-13-D-1-C.XXXX-20-LC																
313	5	1.03	19.62	13	8.4	224	19.98	22	20.78	20.65	8.8	213	250.7	103.5	250.8	30
314	5	1.00	19.94	13	N/A	N/A	20.19	22	21.40	21.22	N/A	N/A	250.7	102.9	250.8	30
Same as previous heading except: Sample IDs: J-13-D-1-C.XXXX-20-HC																
315	5	1.00	19.87	13	8.5	238	20.13	22	21.45	21.34	8.4	220	471.0	198.9	471.4	30
316	5	1.03	19.83	13	N/A	N/A	20.16	22	20.93	20.78	N/A	N/A	471.0	197.7	471.4	30
Air atmosphere, UE-25 p#1 groundwater, Dry-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: P-1-D-1-C.XXXX-20-LC																
321	5	0.99	19.97	13	8.4	247	20.18	22	21.56	21.44	8.4	233	222.8	0.0	222.1	
322	5	1.01	19.95	13	N/A	N/A	20.13	22	21.13	20.99	N/A	N/A	222.8	0.0	222.1	
Same as previous heading except: Sample IDs: P-1-D-1-C.XXXX-20-HC																
323	5	1.04	19.96	13	8.6	260	20.16	22	20.53	20.41	8.7	221	515.1	43.0	519.6	200
324	5	1.01	20.03	13	N/A	N/A	20.17	22	21.13	21.00	N/A	N/A	515.1	48.9	519.6	200
Same as previous complete heading except: Sample IDs: P-1-D-1-C.XXXX-20																
445	9	1.00	19.74	2	8.3	204	20.16	2	21.30	21.13	8.7	201	2536.0	1490.4	2559.0	10
446	9	1.00	19.71	2	N/A	N/A	20.18	2	21.34	21.16	N/A	N/A	2536.0	1496.4	2559.0	10
Betonite																
Air atmosphere, J-13 groundwater, Dry-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: J-13-O-C.XXXX-20																
335	6	1.00	19.92	2	8.3	343	19.85	4	21.17	21.07	8.2	215	444.9	235.3	438.6	20
336	6	1.00	19.77	2	N/A	N/A	19.98	4	21.20	21.11	N/A	N/A	444.9	235.2	438.6	20
389	8	1.01	19.90	5	8.3	244	20.03	2	20.87	20.89	8.5	165	12860.1	8546.5	13219.2	9
390	8	1.01	19.85	5	N/A	N/A	20.01	2	20.81	20.78	N/A	N/A	12860.1	8728.9	13219.2	8
Air atmosphere, UE-25 p#1 groundwater, Dry-sieved (75-500 μm), Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: P-1-O-C.XXXX-20																
353	6	1.02	19.93	2	8.5	264	20.02	4	20.81	20.70	8.6	193	478.8	312.0	514.6	9
354	6	1.03	20.03	2	N/A	N/A	20.07	4	20.83	20.74	N/A	N/A	478.8	312.7	514.6	9
371	7	1.00	20.05	4	8.5	175	20.11	2	21.46	21.39	8.7	201	2234.8	1488.2	2290.4	9
372	7	1.00	20.11	4	N/A	N/A	20.04	2	21.34	21.39	N/A	N/A	2234.8	1493.9	2290.4	9

APPENDIX B: NEPTUNIUM BATCH SORPTION EXPERIMENTAL DATA AND RESULTS

XXXX part of sample ID	Np sorp/ desorp Expt. #	Mass of mineral (g)	Groundwater Pretreatment				Neptunium-237 Solution Sorption Treatment									Distr. Coeff., K_d (mL/g)
			Mass of added water (g)	Period (days)	Final pH	Final Eh	Mass of added soln (g)	Period (days)	Soln/solid ratio (mL/g of solid) Initial	Soln/solid ratio (mL/g of solid) Final	Final pH	Final Eh	Alpha activity in soln (cpm/g of soln) Initial	Alpha activity in soln (cpm/g of soln) Final	Alpha activity in soln (cpm/g of soln) Control	
Albite																
Air atmosphere, J-13 groundwater, Not sieved, Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01 Sample IDs: J-13-P-C.XXXX-20																
479	11	1.00	20.04	2	8.5	124	19.96	2	20.65	20.62	8.5	182	11304.8	10029.6	11075.1	2
480	11	1.00	19.96	2	N/A	N/A	20.00	2	20.79	20.72	N/A	N/A	11304.8	10596.9	11075.1	0.6
539	12	1.03	19.98	2	8.6	184	19.94	3	19.86	19.84	8.3	178	11256.1	10570.4	11333.6	0.8
540	12	1.07	19.83	2	N/A	N/A	19.78	3	19.02	19.02	N/A	N/A	11256.1	10643.3	11333.6	0.5
Same as previous heading except: Sample IDs: J-13 P-C.XXXX																
639	13	1.02	20.05	2	8.3	217	19.69	3	19.99	19.99	8.3	207	8276.5	7889.7	8600.6	0.3
640	13	1.02	19.98	2	N/A	N/A	19.72	3	20.14	19.83	N/A	N/A	8276.5	7876.7	8600.6	0. 5
653	13	1.01	19.93	2	8.3	221	19.74	5	20.19	20.16	8.4	207	8276.5	8108.0	8600.6	−0.2
654	13	1.02	19.91	2	N/A	N/A	19.77	5	20.03	19.96	N/A	N/A	8276.5	8126.8	8600.6	−0.2
667	13	1.01	19.97	2	8.3	235	19.72	7	20.11	20.05	8.6	231	8276.5	8087.2	8600.6	−0.07
668	13	1.02	19.97	2	N/A	N/A	19.70	7	19.95	19.85	N/A	N/A	8276.5	8072.3	8600.6	−0.04
681	13	1.03	20.00	2	8.3	252	19.74	14	19.83	19.73	8.5	215	8276.5	7893.3	8620.3	0.4
682	13	1.02	19.99	2	N/A	N/A	19.64	14	19.84	19.77	N/A	N/A	8276.5	7996.8	8620.3	0.2
695	13	1.03	20.03	2	8.5	220	19.60	21	19.65	19.55	8.6	178	8276.5	8005.8	8620.3	0.1
696	13	1.01	20.02	2	N/A	N/A	20.63	21	21.20	21.09	N/A	N/A	8276.5	7988.2	8620.3	0.08
709	13	1.00	20.08	2	8.3	233	19.62	31	20.31	20.05	8.6	176	8276.5	7870.2	8620.3	0.6
710	13	1.02	20.13	2	N/A	N/A	19.60	31	19.86	19.67	N/A	N/A	8276.5	7883.5	8620.3	0.5

APPENDIX B: NEPTUNIUM BATCH SORPTION EXPERIMENTAL DATA AND RESULTS

XXXX part of sample ID	Np sorp/ desorp Expt. #	Mass of mineral (g)	Groundwater Pretreatment				Neptunium-237 Solution Sorption Treatment									Distr. Coeff., K_d (mL/g)
			Mass of added water (g)	Period (days)	Final pH	Final Eh	Mass of added soln (g)	Period (days)	Soln/solid ratio (mL/g of solid)		Final pH	Final Eh	Alpha activity in soln (cpm/g of soln)			
									Initial	Final			Initial	Final	Control	
Albite (continued)																
Air atmosphere, UE-25 p#1 groundwater, Not sieved, Temperature range: 22–25°C, Data binder: TWS-INC-03-93-01																
Sample IDs: P-1-P-C.XXXX-20																
509	11	1.00	19.94	3	8.9	123	20.02	2	20.66	20.64	8.4	163	1851.1	1741.1	1823.5	0.6
510	11	1.00	19.91	3	N/A	N/A	20.05	2	20.74	20.73	N/A	N/A	1851.1	1728.8	1823.5	0.7
583	12	1.03	19.99	3	8.9	162	20.02	3	20.05	20.06	9.0	173	1748.7	1689.1	1752.0	0.06
584	12	1.02	19.99	3	N/A	N/A	20.05	3	20.32	20.29	N/A	N/A	1748.7	1691.8	1752.0	0.02
Same as previous heading except: Sample IDs: P-1 P-C.XXXX																
723	13	1.01	20.09	2	8.9	199	20.04	3	20.46	20.45	8.8	191	1702.9	1635.8	1755.0	0.2
724	13	1.02	20.12	2	N/A	N/A	20.02	3	20.33	20.32	N/A	N/A	1702.9	1618.3	1755.0	0.3
737	13	1.02	20.15	2	8.9	174	20.00	5	20.21	20.20	9.0	184	1702.9	1657.2	1755.0	−0.05
738	13	1.01	20.12	2	N/A	N/A	20.00	5	20.52	20.50	N/A	N/A	1702.9	1648.7	1755.0	−0.04
751	13	1.01	20.02	2	9.0	198	19.91	7	20.35	20.31	9.1	190	1702.9	1634.3	1755.0	0.2
752	13	1.00	20.01	2	N/A	N/A	19.92	7	20.64	20.60	N/A	N/A	1702.9	1622.8	1755.0	0.3
765	13	1.01	20.14	2	8.9	159	20.04	14	20.51	20.46	9.0	184	1702.9	1628.4	1766.2	0.3
766	13	1.01	20.07	2	N/A	N/A	20.06	14	20.52	20.46	N/A	N/A	1702.9	1634.4	1766.2	0.2
779	13	1.03	20.04	2	8.8	161	19.97	21	19.97	19.80	9.0	161	1702.9	1623.1	1766.2	0.5
780	13	1.02	20.12	2	N/A	N/A	19.96	21	20.19	20.02	N/A	N/A	1702.9	1630.4	1766.2	0.4
793	13	1.02	20.11	2	8.9	171	19.90	31	20.25	20.07	9.0	155	1702.9	1594.1	1766.2	0.8
794	13	1.00	20.16	2	N/A	N/A	19.72	31	20.25	20.02	N/A	N/A	1702.9	1629.3	1766.2	0.6

APPENDIX C

MINERALOGY AND SURFACE AREA OF SOLIDS USED IN SORPTION EXPERIMENTS

APPENDIX C: MINERALOGY AND SURFACE AREA OF SOLIDS USED IN SORPTION EXPERIMENTS

Table 1. Surface Area of Solids

Tuff or mineral	Surface area* (m^2/g)				
	Not ground	Dry-sieved	Wet-sieved with J-13 water Trial #1	Wet-sieved with J-13 water Trial #2	Wet-sieved with UE-25 p#1 water
USW G1-732	2.1	2.7	2.6	2.5	3.3
USW G1-1405	32	28	26		31
USW G1-1936	4.5	4.9	3.6	3.9	3.7
USW G2-767	0.89	1.1	0.62	0.71	0.87
USW G2-1813			34		
USW G2-1951			66		
USW G2-2000			130		
USW G2-2222			100		
USW G4-270	2.0	6.4	5.1		5.0
USW G4-275	2.9	4.5			
USW G4-1506	22	30	27		25
USW G4-1529	37	21	22		31
USW G4-1530	40	41			
USW G4-1625	28	27	28		33
USW G4-1772	23	22	23	23	23
USW G4-2077	19	18			
USW G4-2570	2.8	3.6	2.9	2.9	2.8
USW GU3-747	2.2	2.9	2.8	2.4	2.8
USW GU3-1249	0.52	0.92	0.99		0.87
USW GU3-1407	1.7	3.3	3.0		3.2
USW GU3-1555	12	12	11	11	11
USW GU3-1992			32		
USW GU3-2325	1.8	2.5	2.2	1.8	2.5
Synthetic Calcite	0.13				
Natural Calcite			0.11		0.068
Synthetic Hematite	8.9				
Purified Clinoptilolite	17				
Quartz		0.22	0.26		0.037

*Surface areas reported in YMP Vendor Binder IV, TWS-INC-03-93-02

APPENDIX C: MINERALOGY AND SURFACE AREA OF SOLIDS USED IN SORPTION EXPERIMENTS

Table 2. Mineralogy of Solids

Tuff or mineral	Preparation*	Mineral Percentages																	Data Source**
		Smectite	Clinoptilolite	Mordenite	Hollandite	Opal-CT	Quartz	Feldspar	Mica	Magnetite	Goethite	Hematite	Calcite	Tridymite	Cristobolite	Sepiolite	Hornblende	Glass	
G1-732	Dry-sieved	2 ±1	0	0	0	0	9 ±1	54 ±8	Trace	0	0	Trace	0	4 ±1	27 ±2	0	0	0	a
G1-732	Wet-sieved in J-13	4 ±1	0	0	0	0	9 ±1	55 ±8	Trace	0	0	Trace	0	4 ±1	28 ±2	0	0	0	a
G1-732	Wet-sieved in UE-25 p#1	3 ±1	0	0	0	0	8 ±1	53 ±8	Trace	0	0	Trace	0	5 ±1	27 ±2	0	0	0	a
G1-732	Not ground	5 ±2	0	0	0	0	8 ±1	52 ±7	Trace	0	0	0	0	3 ±1	28 ±2	0	0	0	a
G1-1405	Dry-sieved	1 ±1	70 ±7	4 ±1	0	16 ±4	5 ±1	9 ±2	0	0	0	0	0	0	0	0	0	0	a
G1-1405	Wet-sieved in J-13	1 ±1	68 ±7	4 ±1	0	16 ±4	4 ±1	10 ±2	0	0	0	0	0	0	0	0	0	0	a
G1-1405	Wet-sieved in UE-25 p#1	1 ±1	67 ±6	4 ±1	0	16 ±4	6 ±1	12 ±2	0	0	0	0	0	0	0	0	0	0	a
G1-1405	Not ground	1 ±1	70 ±7	4 ±1	0	16 ±4	5 ±1	9 ±2	0	0	0	0	0	0	0	0	0	0	a
G1-1936	Dry-sieved	2 ±1	0	0	0	0	28 ±2	60 ±8	Trace	0	0	0	0	0	6 ±2	0	0	0	a
G1-1936	Wet-sieved in J-13	2 ±1	0	0	0	0	33 ±2	63 ±9	Trace	0	0	0	0	0	5 ±2	0	0	0	a
G1-1936	Wet-sieved in UE-25 p#1	3 ±1	0	0	0	0	32 ±2	62 ±9	Trace	0	0	0	0	0	5 ±2	0	0	0	a
G1-1936	Not ground	3 ±1	0	0	0	0	31 ±2	61 ±9	Trace	0	0	0	0	0	7 ±2	0	0	0	a
G2-723	Dry-sieved	4 ±1	0	0	0	0	Trace	13 ±2	Trace	0	0	0	34 ±2	0	Trace	0	0	49 ±3	b
G2-767	Dry-sieved	0	0	0	0	0	0	22 ±3	2 ±1	0	0	2 ±1	0	0	Trace	0	0	74 ±3	a
G2-767	Wet-sieved in J-13	0	0	0	0	0	0	22 ±3	2 ±1	0	0	1 ±1	0	0	Trace	0	0	75 ±3	a
G2-767	Wet-sieved in UE-25 p#1	0	0	0	0	0	0	21 ±3	2 ±1	0	0	2 ±1	0	0	Trace	0	0	75 ±3	a
G2-767	Not ground	0	0	0	0	0	0	20 ±3	2 ±1	0	0	2 ±1	0	0	Trace	0	0	76 ±3	a
G2-770	Not ground	<2	0	0	0	0	0	70 ±10	7 ±3	0	0	0	0	0	23 ±7	0	0	0	c
G4-268	Wet-sieved in J-13	0	0	0	0	0	2 ±1	71 ±10	Trace	0	0	1 ±1	0	24 ±2	5 ±3	0	0	0	a
G4-268	Not ground	0	0	0	0	0	1 ±1	69 ±10	Trace	0	0	1 ±1	0	24 ±2	4 ±2	0	0	0	a

*Unless noted otherwise, materials that were dry- or wet-sieved were sieved to obtain particle sizes ranging from 75 to 500 μm; materials that were not ground were also not sieved.

**The complete references for the data sources are listed at the end of the Appendix.

APPENDIX C: MINERALOGY AND SURFACE AREA OF SOLIDS USED IN SORPTION EXPERIMENTS

Tuff or mineral	Preparation	Mineral Percentages																	Data Source
		Smectite	Clinoptilolite	Mordenite	Hollandite	Opal-CT	Quartz	Feldspar	Mica	Magnetite	Goethite	Hematite	Calcite	Tridymite	Cristobolite	Sepiolite	Hornblende	Glass	
G4-270	Dry-sieved	0	0	0	0	0	0	64 ±16	Trace	0	0	1 ±1	0	25 ±2	7 ±3	0	0	0	d
G4-270	Wet-sieved in J-13	0	0	0	0	0	0	65 ±16	Trace	0	0	1 ±1	0	25 ±3	6 ±3	0	0	0	d
G4-270	Wet-sieved in UE-25 p#1	0	0	0	0	0	0	65 ±16	Trace	0	0	1 ±1	0	26 ±3	7 ±4	0	0	0	d
G4-270	Dry-sieved to < 75 µm	0	0	0	0	0	0	68 ±17	Trace	0	0	1 ±1	0	25 ±3	5 ±3	0	0	0	d
G4-270	Not ground	Trace	0	0	0	0	0	66 ±16	Trace	0	0	1 ±1	0	25 ±3	7 ±4			0	d
G4-272	Wet-sieved in J-13	0	0	0	0	0	1 ±1	66 ±9	Trace	0	0	1 ±1	0	22 ±2	7 ±3	0	0	0	a
G4-274	Wet-sieved in UE-25 p#1	Trace	0	0	0	0	1 ±1	61 ±15	Trace	0	0	1 ±1	0	24 ±2	11 ±2	0	0		e
G4-1405	Wet-sieved in J-13	0	0	0	0	0	7 ±1	23 ±3	Trace	0	0	0	0	0	4 ±1	0	0	66 ±3	a
G4-1503	Wet-sieved in J-13	1 ±1	68 ±6	4 ±1	0	15 ±4	5 ±1	10 ±2	0	0	0	0	0	0	0	0	0	0	a
G4-1505	Wet-sieved in J-13	1 ±1	74 ±7	4 ±1	0	13 ±3	3 ±1	11 ±3	0	0	0	0	0	0	0	0	0	0	a
G4-1506	Dry-sieved	2 ±1	65 ±7	6 ±2	0	16 ±4	5 ±1	4 ±1	0	0	0	0	0	0	0	0	0	0	d
G4-1506	Wet-sieved in J-13	2 ±1	62 ±7	6 ±2	0	16 ±4	6 ±1	4 ±1	0	0	0	0	0	0	0	0	0	0	d
G4-1506	Wet-sieved in UE-25 p#1	2 ±1	64 ±7	7 ±2	0	16 ±3	5 ±1	2 ±1	0	0	0	0	0	0	0	0	0	0	d
G4-1506	Dry-sieved to < 75 µm	3 ±1	71 ±8	7 ±2	0	17 ±3	2 ±1	0	0	0	0	0	0	0	0	0	0	0	d
G4-1506	Not ground	4 ±1	64 ±7	6 ±2	0	22 ±5	3 ±1	2 ±1	0	0	0	0	0	0	0	0	0	0	d
G4-1507	Not ground	5 ±2	65 ±6	3 ±1	0	19 ±4	6 ±1	4 ±1	0	0	0	0	0	0	0	0	0	0	e
G4-1508	Wet-sieved in J-13	2 ±1	68 ±7	6 ±2	0	16 ±4	5 ±1	9 ±2	0	0	0	0	0	0	0	0	0	0	a
G4-1510	Wet-sieved in J-13	1 ±1	59 ±7	10 ±3	0	17 ±4	5 ±1	11 ±3	0	0	0	0	0	0	0	0	0	0	a
G4-1529	Dry-sieved	1 ±1	64 ±8	11 ±3	0	14 ±3	5 ±1	9 ±2	0	0	0	0	0	0	0	0	0	0	a
G4-1529	Wet-sieved in J-13	1 ±1	59 ±8	13 ±4	0	14 ±3	7 ±1	9 ±2	0	0	0	0	0	0	0	0	0	0	a
G4-1529	Wet-sieved in UE-25 p#1	1 ±1	66 ±8	11 ±3	0	13 ±3	5 ±1	8 ±2	0	0	0	0	0	0	0	0	0	0	a
G4-1529	Not ground	1 ±1	67 ±9	12 ±4	0	13 ±3	4 ±1	8 ±2	0	0	0	0	0	0	0	0	0	0	a

APPENDIX C: MINERALOGY AND SURFACE AREA OF SOLIDS USED IN SORPTION EXPERIMENTS

Tuff or mineral	Preparation	Mineral Percentages																	Data Source
		Smectite	Clinoptilolite	Mordenite	Hollandite	Opal-CT	Quartz	Feldspar	Mica	Magnetite	Goethite	Hematite	Calcite	Tridymite	Cristobolite	Sepiolite	Hornblende	Glass	
G4-1530	Dry-sieved	2 ±1	55 ±7	12 ±4	0	16 ±4	7 ±1	7 ±2	0	0	0	0	0	0	0	0	0	0	e
G4-1608	Dry-sieved	6 ±2	65 ±6	3 ±1	0	21 ±5	4 ±1	4 ±1	0	0	0	0	0	0	0	0	0	0	e
G4-1608	Dry-sieved to < 75 µm	6 ±2	70 ±7	4 ±2	0	18 ±4	1 ±1	3 ±1	0	0	0	0	0	0	0	0	0	0	e
G4-1625	Dry-sieved	3 ±1	69 ±8	8 ±3	0	13 ±3	5 ±1	7 ±2	0	0	0	0	0	0	0	0	0	0	a
G4-1625	Wet-sieved in J-13	2 ±1	61 ±7	9 ±3	0	14 ±4	5 ±1	10 ±2	0	0	0	0	0	0	0	0	0	0	a
G4-1625	Wet-sieved in UE-25 p#1	2 ±1	66 ±8	8 ±3	0	15 ±4	6 ±1	9 ±2	0	0	0	0	0	0	0	0	0	0	a
G4-1625	Not ground	2 ±1	74 ±8	8 ±3	0	13 ±3	3 ±1	5 ±1	0	0	0	0	0	0	0	0	0	0	a
G4-1711	Not ground	2 ±1	50 ±6	9 ±3	0	17 ±4	10 ±1	11 ±2	0	0	0	0	0	0	0	0	0	0	e
G4-1772	Dry-sieved	4 ±1	66 ±5	0	0	23 ±6	2 ±1	11 ±2	Trace	0	0	0	0	0	0	0	0	0	a
G4-1772	Wet-sieved in J-13	3 ±1	63 ±5	0	0	22 ±6	2 ±1	11 ±2	Trace	0	0	0	0	0	0	0	0	0	a
G4-1772	Wet-sieved in UE-25 p#1	3 ±1	66 ±5	0	0	23 ±6	1 ±1	12 ±2	Trace	0	0	0	0	0	0	0	0	0	a
G4-1772	Not ground	4 ±1	61 ±5	0	0	26 ±7	2 ±1	11 ±2	Trace	0	0	0	0	0	0	0	0	0	a
G4-2077	Dry-sieved	1 ±1	50 ±8	16 ±5	0	14 ±4	3 ±1	18 ±5	0	0	0	0	0	0	0	0	0	0	a
G4-2077	Wet-sieved in J-13	1 ±1	51 ±8	15 ±5	0	14 ±4	3 ±1	21 ±6	0	0	0	0	0	0	0	0	0	0	a
G4-2077	Wet-sieved in UE-25 p#1	1 ±1	47 ±8	17 ±5	0	15 ±4	3 ±1	19 ±5	0	0	0	0	0	0	0	0	0	0	a
G4-2077	Not ground	1 ±1	52 ±8	17 ±5	0	14 ±4	2 ±1	16 ±4	0	0	0	0	0	0	0	0	0	0	a
G4-2570	Dry-sieved	0	0	0	0	0	38 ±2	59 ±8	1 ±1	0	0	1 ±1	0	0	0	0	0	0	a
G4-2570	Wet-sieved in J-13	0	0	0	0	0	42 ±2	60 ±8	1 ±1	0	0	Trace	0	0	0	0	0	0	a
G4-2570	Wet-sieved in UE-25 p#1	0	0	0	0	0	43 ±2	58 ±8	1 ±1	0	0	Trace	0	0	0	0	0	0	a
G4-2570	Not ground	1 ±1	0	0	0	0	37 ±2	58 ±8	0	0	0	1 ±1	0	0	0	0	0	0	a
GU3-747	Dry-sieved	2 ±1	0	0	0	0	0	55 ±8	Trace	0	0	Trace	0	5 ±1	32 ±2	0	0	0	a
GU3-747	Wet-sieved in J-13	2 ±1	0	0	0	0	0	56 ±8	Trace	0	0	Trace	0	6 ±1	31 ±2	0	0	0	a
GU3-747	Wet-sieved in UE-25 p#1	3 ±1	0	0	0	0	0	53 ±7	Trace	0	0	1 ±1	0	5 ±1	31 ±2	0	0	0	a
GU3-747	Not ground	3 ±1	0	0	0	0	0	57 ±8	Trace	0	0	Trace	0	4 ±1	33 ±2	0	0	0	a

APPENDIX C: MINERALOGY AND SURFACE AREA OF SOLIDS USED IN SORPTION EXPERIMENTS

Tuff or mineral	Preparation	Mineral Percentages																	Data Source
		Smectite	Clinoptilolite	Mordenite	Hollandite	Opal-CT	Quartz	Feldspar	Mica	Magnetite	Goethite	Hematite	Calcite	Tridymite	Cristobolite	Sepiolite	Hornblende	Glass	
GU3-751	Dry-sieved	1 ±1	0	0	0	0	1 ±1	59 ±9	Trace	0	0	Trace	0	8 ±1	29 ±3	0	0	0	e
GU3-1249	Dry-sieved	0	0	0	0	14 ±4	1 ±1	11 ±2	Trace	0	0	0	0	0	0	0	0	74 ±4	a
GU3-1249	Wet-sieved in J-13	0	0	0	0	15 ±4	1 ±1	12 ±2	Trace	0	0	0	0	0	0	0	0	72 ±2	a
GU3-1249	Wet-sieved in UE-25 p#1	0	0	0	0	14 ±4	1 ±1	12 ±2	Trace	0	0	0	0	0	0	0	0	73 ±4	a
GU3-1249	Not ground	0	0	0	0	16 ±4	1 ±1	13 ±2	Trace	0	0	0	0	0	0	0	0	70 ±4	a
GU3-1394	Dry-sieved	0	0	0	0	1 ±1	1 ±1	3 ±1	Trace	0	0	0	0	0	0	0	0	95 ±2	d
GU3-1405	Not ground	1 ±1	0	0	0	0	2 ±1	10 ±1	0	0	0	Trace	0	0	2 ±1	0	0	85 ±2	a
GU3-1407	Dry-sieved	1 ±1	0	0	0	0	4 ±1	14 ±2	Trace	0	0	Trace	0	0	1 ±1	0	0	80 ±2	a
GU3-1407	Wet-sieved in J-13	1 ±1	0	0	0	0	5 ±1	14 ±2	Trace	0	0	0	0	0	1 ±1	0	0	79 ±2	a
GU3-1407	Wet-sieved in UE-25 p#1	1 ±1	0	0	0	0	5 ±1	11 ±2	Trace	0	0	0	0	0	2 ±1	0	0	81 ±2	a
GU3-1407	Not ground	1 ±1	0	0	0	0	5 ±1	11 ±2	Trace	0	0	0	0	0	2 ±1	0	0	81 ±2	a
GU3-1555	Dry-sieved	6 ±2	2 ±1	0	0	0	5 ±1	25 ±4	1 ±1	0	0	0	0	0	0	0	1 ±1	59 ±5	a
GU3-1555	Wet-sieved in J-13	5 ±2	1 ±1	0	0	0	5 ±1	30 ±4	1 ±1	0	0	0	0	0	0	0	1 ±1	56 ±5	a
GU3-1555	Wet-sieved in UE-25 p#1	4 ±1	1 ±1	0	0	0	4 ±1	24 ±4	1 ±1	0	0	0	0	0	0	0	1 ±1	64 ±3	a
GU3-1555	Not ground	9 ±3	1 ±1	0	0	0	4 ±1	27 ±4	1 ±1	0	0	0	0	0	0	0	1 ±1	56 ±5	a
GU3-2174	Dry-sieved	2 ±1	0	0	0	0	19 ±1	63 ±7	1 ±1	0	0	1 ±1	0	0	13 ±1	0	0	0	e
GU3-2325	Dry-sieved	0	0	0	0	0	24 ±2	60 ±8	2 ±1	0	0	Trace	0	0	14 ±1	0	0	0	a
GU3-2325	Wet-sieved in J-13	1 ±1	0	0	0	0	23 ±2	56 ±8	1 ±1	0	0	1 ±1	0	0	14 ±1	0	0	0	a
GU3-2325	Wet-sieved in UE-25 p#1	0	0	0	0	0	26 ±2	54 ±8	2 ±1	0	0	Trace	0	0	14 ±1	0	0	0	a
GU3-2325	Not ground	1 ±1	0	0	0	0	25 ±2	56 ±8	1 ±1	0	0	Trace	0	0	14 ±1	0	0	0	a
Synthetic calcite (A)	Not sieved	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	d

APPENDIX C: MINERALOGY AND SURFACE AREA OF SOLIDS USED IN SORPTION EXPERIMENTS

Tuff or mineral	Preparation	Mineral Percentages																	Data Source
		Smectite	Clinoptilolite	Mordenite	Hollandite	Opal-CT	Quartz	Feldspar	Mica	Magnetite	Goethite	Hematite	Calcite	Tridymite	Cristobolite	Sepiolite	Hornblende	Glass	
Natural calcite (B)	Dry-sieved	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	d
	Wet-sieved in J-13	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	d
	Wet-sieved in UE-25 p#1	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	d
Synthetic Hematite (C)	Not sieved	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	d
Montmorillonite (D-1)	Dry-sieved	95+	0	0	0	0	Trace	Trace	0	0	0	0	0	0	0	0	0		d
Purified Clinoptilolite (G)	Not sieved	0	95+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	d
Quartz (M)	Dry-sieved	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	d
	Wet-sieved in J-13	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	d
	Wet-sieved in UE-25 p#1	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	d
Bentonite (O)	Dry-sieved	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	d

Data Source References

a: Binder # TWS-INC-11-93-32

b: Los Alamos Laboratory report LA-11669-MS (Chipera, S.J. and D.L. Bish. September 1989. Quantitative x-ray diffraction analyses of samples used for sorption studies by the Isotope and Nuclear Chemistry Division.)

c: Los Alamos Laboratory report LA-11497-MS (Bish, D.L. and S.J. Chipera. March 1989. Revised mineralogic summary of Yucca Mountain, Nevada.)

d: Binder # TWS-INC-03-93-02

e: Binder # TWS-INC11-9/82-54