

Radionuclides and Inorganics in Selected Drinking Water Sources

Introduction

The water wells in the immediate vicinity of the WIPP site provide water primarily for livestock, industrial usage by oil and gas production operations, and monitoring studies conducted by various groups. In May and July 2001, water samples were collected for CEMRC environmental monitoring studies from five sources in the region of the WIPP. The sources included the community water supplies of Carlsbad, Loving, Otis, and Hobbs; and the water supply for the WIPP site (Double Eagle). In past years a sixth source, a private well (Private Well #2), was sampled; however, during the 2001 sampling period that well was dry, and thus no sample was obtained.

Aquifers in the region surrounding the WIPP include Dewey Lake, Culebra-Magenta, Ogalalla, Dockum, Pecos River alluvium and Capitan Reef. The main Carlsbad water supply is the Sheep Draw well field whose primary source is the Capitan Reef aquifer. The Hobbs and WIPP-Double Eagle water supplies are drawn from the Ogalalla aquifer, while the Loving/Malaga and Otis supply wells draw from deposits that are hydraulically linked to the flow of the Pecos River.

The 2001 drinking water samples were collected after WIPP began receiving both radioactive waste (March 1999) and mixed waste (September 2000). Therefore, this summary represents monitoring phase data for both radionuclides and non-radiological constituents in drinking water.

CEMRC began collecting drinking water samples in 1997, and summaries of methods, data and results from previous sampling were reported in the CEMRC 1997, 1998, 1999 and 2000 reports (available at <http://www.cemrc.org>). The results of previous analyses of drinking water were generally consistent for each source across sampling periods, with few organic contaminants detected and inorganic

substances mostly below levels specified under the Safe Drinking Water Act.

Methods

All 2001 samples were collected according to EPA protocols for the collection, handling and preservation of drinking water as follows: (1) 4 L for radiological analyses, (2) 1 L for elemental analyses and (3) 1 L for anion tests. None of the samples were filtered before analysis, but a portion of the 4-L sample was transferred to a 3-L Marinelli beaker for gamma spectroscopy analyses. The 2001 samples were collected at the same locations as the 2000 samples except for Private Well #2.

CEMRC performed non-radiological analyses of drinking water samples using IC, ICP-MS and AAS. Instrumentation, general methods and QA/QC results are presented in Appendix K. CEMRC did not test the 2001 drinking water samples for organic constituents because of low concentrations and consistent results in prior analyses performed by an external laboratory.

Radiological analyses were carried out at CEMRC by first counting the samples in Marinelli beakers using a coaxial, high purity Ge detector system to determine gamma-emitting radionuclide activity concentrations. Radiochemistry was then applied to each sample for actinide separation and purification using multiple precipitation, co-precipitation and ion-exchange and/or extraction chromatography. Once the actinides were separated elementally, they were co-precipitated with LaF₃ and deposited onto filters, which were then counted on an alpha spectroscopy system. Radioanalytical QA/QC data are presented in Appendix L.

Results and Discussion

Radiological

The only radionuclides measured above MDC in 2001 samples as determined by gamma spectroscopy targeting 11 naturally

occurring and 12 anthropogenic gamma-emitters, were ^{214}Bi and ^{214}Pb (in samples from Double Eagle, Hobbs, Loving and Otis). These two nuclides were produced through the decay of ^{222}Rn present in the water. The source of ^{222}Rn was decay of ^{226}Ra contained in materials (soils, sediments, etc.) with which the water had been in contact prior to sampling. Neither ^{214}Pb nor ^{214}Bi could be used to quantify the ^{222}Rn activity in the water since the Marinelli beakers used in the counting of the samples did not provide an adequate seal to prevent the loss of ^{222}Rn gas, thus preventing the establishment of secular equilibrium. In previous years a longer period of time had elapsed between sample collections and counting, which allowed these two radionuclides to decay below detection. Thus, the activities for these two radionuclides were not previously reported.

Three naturally occurring actinides (^{234}U , ^{235}U and ^{238}U) were detected via alpha spectroscopy in all of the samples from each location. The uranium isotope activity concentrations in 2001 water samples were quite similar to the 2000, 1999 and 1998 samples, with the greatest variations appearing in ^{235}U measurements. Measured values for samples collected during 2001 were 31-162 mBq L^{-1} for ^{234}U , 0.95-3.3 mBq L^{-1} for ^{235}U , and 12-60 mBq L^{-1} for ^{238}U . The highest levels of all three uranium isotopes for each year studied were in samples from Otis (Fig. 27-29). Across all years, ^{234}U concentrations were 3.2-3.4 times greater than ^{238}U in samples from Loving, and 2.3-2.8 times greater in samples from the other four drinking water sources. Enrichment of ^{234}U compared to ^{238}U at these levels is common in drinking water produced from underground sources (Eisenbud, M. and T. Gesell, 1997, *Environmental Radioactivity*, Academic Press, San Diego).

For ^{235}U , the levels measured in 2001 were higher than in 1998, 1999 and 2000 (5 to 32% RPD) for samples from Carlsbad, Hobbs and Otis. A similar or lower level of ^{235}U (-0.8 to -7% RPD) was measured in the 2001 sample from Loving as compared to samples from 1998, 1999 and 2000. The ^{235}U level in the 2001 sample for Double Eagle is lower compared to samples from 1998, 1999 and

2000 (-13 to -39% RPD). For ^{234}U , the 2001 sample from Otis was higher than levels measured in 1998, 1999 and 2000 (8 to 23% RPD). For Double Eagle, Hobbs and Loving, the ^{234}U levels measured in 2001 samples were lower (-1 to -42% RPD) than in 1998, 1999 and 2000 samples. The ^{234}U activity in the 2001 sample from Carlsbad was higher compared to samples from 1999 and 2000 (6 to 7% RPD) but lower than in 1998 (-6% RPD). For ^{238}U , the 2001 samples from Double Eagle and Hobbs were lower (-14 to -31% RPD) than 1998, 1999 and 2000, while Otis was higher than in the previous three years (13 to 25% RPD). The value for Carlsbad was lower (-11% RPD) in 2001 compared to 1998, while the value for Loving was higher (3% RPD) compared to 1998.

The ranges and ratios of all three uranium isotopes measured in CEMRC samples during 1998-2001 were similar to values from 1992 samples from Carlsbad, Double Eagle and Loving reported by EEG (Kenney, J.W., 1994, *Preoperational Radiation Surveillance of the WIPP Project by EEG during 1992*, EEG-54). No comparable data for community drinking water sources have been generated in recent years by Westinghouse Waste Isolation Division (WID), the WIPP management and operating contractor.

The levels and ratios measured by CEMRC for these naturally occurring radionuclides are typical of natural variations in ground water (Cothorn, C.R. and W.L. Lappenbusch, 1983, *Health Physics* 45, 89; Luo et al., 2000, *Geochim. Cosmochim.* 64, 867), and agree well with the few directly comparable values reported from studies in the region. Overall the CEMRC measurements are more consistent through time for each source than the cited annual measurements reported by WID. It is important to note that the quantification of ^{235}U by alpha spectroscopy may be impacted by tailing from the ^{234}U spectral region. As previously noted, values for samples collected in 1998 are believed to have been affected by storage of the samples for > 12 months prior to analyses. Despite acidification, such prolonged storage may have allowed U adsorption to the containers, producing a low bias in measured U.

Of the 15 uranium isotope measurements in 2001 samples, only 6 were higher than in 1998 samples (compared with 11 measurements in 2000 that were higher than the 1998 levels). Of these, five values (^{235}U for Carlsbad, Hobbs and Otis and ^{234}U and ^{238}U for Otis) were above 2 SD (counting error) of the matching 1998 value. Based on the comparisons as summarized, other relevant scientific information and results of analyses of other media reported herein, CEMRC concludes that the higher levels of some uranium isotopes in the 2001 drinking water samples from some sources represent a combination of natural variation and analytical artifact, and are not the result of releases from the WIPP.

Pu was not detected in any 2001 drinking water samples. Results of previous tests using thermal ionization mass spectrometry revealed no Pu in samples from the same six drinking water sources (reported in the CEMRC 1999 Report).

Non-Radiological Results

Measurements of inorganic analytes produced by CEMRC from the five drinking water sources showed little variation between years for each source. Differences of > 100% between the results for samples from 2001 and previous monitoring years have been recorded for Ca, Ce, Cu, La, Mg, Nd and fluoride at a single sampling location. For Co, Na, Sr, Zn and chloride, differences > 100% have been recorded in samples from two sources, while for Al, Fe and Mn, differences >100% were recorded in samples from three sources.

With the exception of these instances, the 1998-2001 measurements exhibit a high level of consistency that provides a useful characterization of each source (Table 16-18). In past years (1998-2000) samples from Otis exhibited higher levels of Sr, Na, Mg, K, Co, Cu and Ca compared to the other sampling sources (except for Private Well #2). This trend continued for 2001 with the exception of Cu. The level of Cu was higher in the sample from Carlsbad ($6.9 \mu\text{g L}^{-1}$) in 2001 compared to the other sites. Otis had the highest levels of Zn ($16 \mu\text{g L}^{-1}$) and total U ($5.3 \mu\text{g L}^{-1}$ measured by ICP-MS), while measured levels of Ba ($14 \mu\text{g L}^{-1}$) were lowest in this source. Total nitrates (not reduced to N) were highest

in samples from Otis ($9.6\text{-}22 \text{ mg L}^{-1}$) and Loving ($17\text{-}23 \text{ mg L}^{-1}$) for all sampling years. Across all years, samples from Loving were highest in measured Pb levels ($1.0\text{-}1.7 \mu\text{g L}^{-1}$), while Hg was detected only in samples from Hobbs ($0.011\text{-}0.014 \mu\text{g L}^{-1}$). Measured As levels were highest in samples from Hobbs ($4.9\text{-}7.45 \mu\text{g L}^{-1}$) and Double Eagle ($5.2\text{-}7.4 \mu\text{g L}^{-1}$), and these measurements suggest that these drinking water sources would exceed any As standard $\leq 5 \mu\text{g L}^{-1}$ as has been recently considered for adoption by EPA.

As in previous years, measured levels of chloride and sulfate exceeded reference levels (secondary maximum contaminant levels) in the 2001 samples from Otis.

These results are not appropriate for use in assessing regulatory compliance, due to sample collection locations and other methodological details. However, it is noteworthy that the CEMRC results for Carlsbad and Double Eagle drinking water collected during 1998-2001 generally agreed well with measurements published by the City of Carlsbad Municipal Water System (2000 *Annual Consumer Report on the Quality of Your Drinking Water*, 1999 *Annual Consumer Report on the Quality of Tap Water*; 1998 *Annual Consumer Report on the Quality of Tap Water*) and with measurements published by the Otis Water User Co-Op (*Annual Water Quality Report*, 1999). As noted in the CEMRC 1999 Report, CEMRC values for nitrates are higher than those reported by Carlsbad and Loving, because the city-reported values are actually total N, rather than total nitrates. Based on these comparisons and the results of the analyses of the other media reported in this document, CEMRC concludes the higher levels of some inorganic analytes in the 2001 drinking water sources are not the result of releases from the WIPP.

It should be noted that concentrations for inorganic analytes reported in the CEMRC 2000 Report were not blank-corrected. The values reported in Table 16-18 in this document have been corrected for blank contributions, and therefore concentrations may not be directly comparable to those previously reported.

Table 16. Range of Concentrations of Selected Inorganic Analytes in Drinking Water Samples Collected from Carlsbad and Double Eagle during 1998-2001

Analyte	Unit	Carlsbad				Double Eagle			
		1998-2000			Concentration 2001	1998-2000			Concentration 2001
		^a N	^b Min	^c Max		N	Min	Max	
Ag	µg L ⁻¹	1	1.75E-02	1.75E-02	^d NA	0	NA	NA	NA
Al	µg L ⁻¹	2	2.34E+00	3.17E+01	3.68E+00	3	6.76E-01	7.22E+01	6.08E+00
As	µg L ⁻¹	3	5.67E-01	6.82E-01	NA	3	5.21E+00	7.42E+00	5.60E+00
Ba	µg L ⁻¹	3	6.83E+01	6.96E+01	6.64E+01	2	7.97E+01	8.96E+01	1.25E+02
Be	µg L ⁻¹	0	NA	NA	NA	1	3.63E-02	3.63E-02	NA
Ca	µg L ⁻¹	3	7.26E+04	7.98E+04	8.06E+04	3	5.08E+03	5.83E+04	5.11E+04
Cd	µg L ⁻¹	0	NA	NA	NA	0	NA	NA	NA
Ce	µg L ⁻¹	0	NA	NA	NA	0	NA	NA	3.63E-03
Co	µg L ⁻¹	2	1.83E-01	3.41E-01	8.80E-02	2	9.31E-02	1.37E-01	NA
Cr	µg L ⁻¹	2	2.68E+00	4.01E+00	3.81E+00	2	2.94E+00	3.20E+00	1.29E+00
Cu	µg L ⁻¹	2	1.81E+00	4.29E+00	6.90E+00	2	1.19E+00	4.84E+00	2.54E+00
Dy	µg L ⁻¹	0	NA	NA	NA	0	NA	NA	NA
Eu	µg L ⁻¹	2	1.80E-02	2.42E-02	1.35E-02	2	1.88E-02	2.58E-02	2.70E-02
Fe	µg L ⁻¹	1	2.07E+00	2.07E+00	NA	2	1.98E+00	7.93E+01	1.48E+02
Gd	µg L ⁻¹	0	NA	NA	NA	0	NA	NA	NA
Hg	µg L ⁻¹	0	NA	NA	NA	0	NA	NA	NA
K	µg L ⁻¹	3	1.27E+03	2.91E+03	3.56E+03	3	2.66E+03	2.94E+04	2.62E+03
La	µg L ⁻¹	2	1.35E-02	4.42E-02	NA	2	1.59E-02	6.26E-02	1.19E-02
Li	µg L ⁻¹	2	7.25E+00	7.87E+00	7.41E+00	3	1.81E+01	1.90E+01	1.37E+01
Mg	µg L ⁻¹	2	3.14E+04	3.40E+04	3.43E+04	2	1.09E+03	1.07E+04	9.21E+03
Mn	µg L ⁻¹	3	5.50E-02	3.37E-01	9.40E-01	2	2.30E-01	3.52E-01	8.73E-01
Mo	µg L ⁻¹	3	7.03E-01	1.20E+00	8.93E-01	2	1.42E+00	1.66E+00	1.48E+00
Na	µg L ⁻¹	3	1.97E+04	9.94E+04	4.55E+04	3	3.84E+03	3.25E+04	2.35E+04
Nd	µg L ⁻¹	0	NA	NA	NA	0	NA	NA	NA
Ni	µg L ⁻¹	2	2.13E+00	2.84E+00	1.46E+00	2	1.44E+00	1.72E+00	1.66E+00
Pb	µg L ⁻¹	2	3.76E-01	1.44E+00	6.32E-01	2	3.16E-01	1.38E+00	6.92E-01
Pr	µg L ⁻¹	0	NA	NA	NA	0	NA	NA	NA
Sb	µg L ⁻¹	1	1.99E-01	1.99E-01	NA	3	2.41E-02	1.39E-01	NA
Sc	µg L ⁻¹	1	1.82E+00	1.82E+00	1.57E+00	1	5.27E+00	5.27E+00	4.61E+00
Se	µg L ⁻¹	0	NA	NA	NA	0	NA	NA	3.41E+00
Sm	µg L ⁻¹	2	2.34E-02	2.57E-02	3.39E-02	2	2.83E-02	3.70E-02	3.31E-02
Sn	µg L ⁻¹	0	NA	NA	5.97E-02	1	3.36E-01	3.36E-01	NA
Sr	µg L ⁻¹	3	3.53E+02	4.59E+02	3.59E+02	3	5.06E+01	5.28E+02	5.53E+02

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Table 16. Range of Concentrations of Selected Inorganic Analytes in Drinking Water Samples Collected from Carlsbad and Double Eagle during 1998-2001 (Cont.)

Analyte	Unit	Carlsbad				Double Eagle			
		1998-2000			Concentration 2001	1998-2000			Concentration 2001
		^a N	^b Min	^c Max		N	Min	Max	
Th	µg L ⁻¹	1	1.76E-02	1.76E-02	NA	1	2.07E-03	2.07E-03	NA
Ti	µg L ⁻¹	0	NA	NA	1.60E+00	0	NA	NA	2.87E+00
Tl	µg L ⁻¹	2	1.11E-01	1.20E-01	1.54E-01	0	NA	NA	NA
U	µg L ⁻¹	2	8.21E-01	8.42E-01	8.43E-01	2	1.75E+00	1.77E+00	1.48E+00
V	µg L ⁻¹	3	3.82E+00	4.69E+00	4.59E+00	2	2.65E+01	2.70E+01	2.80E+01
Zn	µg L ⁻¹	3	4.52E+00	1.52E+01	7.11E+00	2	1.46E+00	5.19E+00	1.25E+01
Chloride	µg L ⁻¹	3	1.53E+04	1.88E+05	6.65E+04	3	2.58E+04	3.69E+04	2.43E+04
Fluoride	µg L ⁻¹	3	2.18E+02	7.81E+02	5.36E+02	3	5.01E+02	9.71E+02	7.86E+02
Nitrate	µg L ⁻¹	3	3.52E+03	5.91E+03	4.06E+03	3	1.07E+04	1.36E+04	1.20E+04
Sulfate	µg L ⁻¹	3	8.07E+04	1.17E+05	9.96E+04	3	4.12E+04	5.69E+04	4.09E+04

^aN = number of samples > MDL (1998-2000)

^bMin = minimum measured concentration in annual samples from 1998-2000

^cMax = maximum measured concentration in annual samples from 1998-2000

^dNA = all samples below MDL for analyte

Table 17. Range of Concentrations of Selected Inorganic Analytes in Drinking Water Samples Collected from Hobbs and Loving during 1998-2001

Analyte	Unit	Hobbs				Loving			
		1998-2000			Concentration 2001	1998-2000			Concentration 2001
		^a N	^b Min	^c Max		N	Min	Max	
Ag	µg L ⁻¹	1	3.86E-03	3.86E-03	^d NA	2	2.55E-03	3.28E-03	NA
Al	µg L ⁻¹	3	3.03E+00	1.14E+02	8.62E+00	2	1.30E+00	1.56E+00	3.76E+00
As	µg L ⁻¹	3	5.71E+00	7.37E+00	4.91E+00	3	1.48E+00	1.85E+00	1.67E+00
Ba	µg L ⁻¹	3	5.65E+01	5.99E+01	5.98E+01	3	2.90E+01	3.03E+01	3.01E+01
Be	µg L ⁻¹	1	5.39E-02	5.39E-02	NA	1	9.35E-02	9.35E-02	NA
Ca	µg L ⁻¹	3	7.99E+03	9.06E+04	7.79E+04	3	9.04E+03	1.04E+05	9.02E+04
Cd	µg L ⁻¹	1	4.34E-03	4.34E-03	NA	0	NA	NA	NA
Ce	µg L ⁻¹	3	5.87E-03	2.23E-02	5.10E-03	1	9.74E-04	9.74E-04	NA
Co	µg L ⁻¹	3	2.01E-01	3.61E-01	9.78E-02	3	1.48E-01	2.48E-01	1.02E-01
Cr	µg L ⁻¹	3	2.28E+00	3.10E+00	1.18E+00	3	2.51E+00	4.28E+00	1.91E+00
Cu	µg L ⁻¹	3	1.87E+00	2.70E+00	1.06E+00	3	2.35E+00	5.59E+00	2.11E+00
Dy	µg L ⁻¹	0	NA	NA	4.18E-03	0	NA	NA	NA
Eu	µg L ⁻¹	3	1.37E-02	1.97E-02	1.31E-02	3	7.00E-03	1.01E-02	7.92E-03
Fe	µg L ⁻¹	3	2.10E+00	6.70E+01	1.74E+02	0	NA	NA	2.24E+02
Gd	µg L ⁻¹	0	NA	NA	NA	1	2.15E-03	2.15E-03	NA
Hg	µg L ⁻¹	2	1.06E-02	1.42E-02	NA	0	NA	NA	NA
K	µg L ⁻¹	3	2.44E+03	2.52E+04	2.59E+03	2	1.95E+03	2.45E+03	2.13E+03
La	µg L ⁻¹	3	1.45E-02	5.01E-02	NA	3	6.66E-03	2.22E-02	NA
Li	µg L ⁻¹	3	2.92E+01	3.18E+01	2.65E+01	3	1.85E+01	1.96E+01	1.72E+01
Mg	µg L ⁻¹	2	2.11E+03	2.00E+04	1.92E+04	2	4.04E+03	3.83E+04	3.88E+04
Mn	µg L ⁻¹	3	3.79E-01	6.69E-01	6.73E-01	3	1.43E-02	8.59E-02	6.24E-02
Mo	µg L ⁻¹	3	2.46E+00	2.72E+00	3.07E+00	3	1.28E+00	1.57E+00	1.58E+00
Na	µg L ⁻¹	3	4.97E+03	4.75E+04	4.24E+04	3	2.33E+03	2.11E+04	1.96E+04
Nd	µg L ⁻¹	3	3.01E-03	1.28E-02	NA	1	3.37E-03	3.37E-03	NA
Ni	µg L ⁻¹	3	2.22E+00	2.64E+00	1.67E+00	3	2.71E+00	3.38E+00	2.03E+00
Pb	µg L ⁻¹	3	9.82E-02	1.70E-01	9.44E-02	3	1.03E+00	1.67E+00	1.01E+00
Pr	µg L ⁻¹	1	1.57E-03	1.57E-03	NA	0	NA	NA	NA
Sb	µg L ⁻¹	2	3.88E-02	7.02E-02	6.15E-02	2	6.78E-02	1.84E-01	NA
Sc	µg L ⁻¹	1	8.58E+00	8.58E+00	7.17E+00	1	3.22E+00	3.22E+00	3.40E+00
Se	µg L ⁻¹	0	NA	NA	3.50E+00	0	NA	NA	NA
Sm	µg L ⁻¹	3	2.20E-02	3.02E-02	1.93E-02	3	8.43E-03	1.30E-02	NA
Sn	µg L ⁻¹	0	NA	NA	NA	1	4.45E-01	4.45E-01	NA
Sr	µg L ⁻¹	3	7.89E+01	9.23E+02	8.86E+02	3	7.60E+01	8.32E+02	8.55E+02

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Table 17. Range of Concentrations of Selected Inorganic Analytes in Drinking Water Samples Collected from Hobbs and Loving during 1998-2001 (Cont.)

Analyte	Unit	Hobbs				Loving			
		1998-2000			Concentration 2001	1998-2000			Concentration 2001
		^a N	^b Min	^c Max		N	Min	Max	
Th	µg L ⁻¹	2	2.29E-03	4.56E-03	NA	2	5.69E-03	7.38E-03	NA
Ti	µg L ⁻¹	0	NA	NA	4.64E+00	0	NA	NA	2.68E+00
Tl	µg L ⁻¹	0	NA	NA	2.24E-02	0	NA	NA	4.32E-02
U	µg L ⁻¹	3	2.90E+00	3.39E+00	3.23E+00	3	1.98E+00	2.11E+00	2.26E+00
V	µg L ⁻¹	4	3.24E+01	3.56E+01	3.63E+01	3	1.22E+01	1.27E+01	1.20E+01
Zn	µg L ⁻¹	3	8.44E-01	4.37E+00	2.06E+00	3	4.79E+00	9.03E+00	9.01E+00
Chloride	µg L ⁻¹	3	6.32E+04	9.36E+04	7.40E+04	3	1.59E+04	2.94E+04	2.50E+04
Fluoride	µg L ⁻¹	3	6.19E+02	1.33E+03	1.15E+03	3	2.45E+02	6.45E+02	6.10E+02
Nitrate	µg L ⁻¹	3	1.70E+04	2.01E+04	1.58E+04	3	1.72E+04	2.32E+04	1.66E+04
Sulfate	µg L ⁻¹	3	1.04E+05	1.42E+05	9.60E+04	3	1.45E+05	2.05E+05	1.56E+05

^aN = number of samples > MDL (1998-2000)^bMin = minimum measured concentration in annual samples from 1998-2000^cMax = maximum measured concentration in annual samples from 1998-2000^dNA = all samples below MDL for analyte

Table 18. Range of Concentrations of Selected Inorganic Analytes in Drinking Water Samples Collected Otis during 1998-2001

Analyte	Unit	Otis			
		1998-2000			Concentration 2001
		^a N	^b Min	^c Max	
Ag	µg L ⁻¹	1	2.63E-02	2.63E-02	^d NA
Al	µg L ⁻¹	1	1.42E+00	1.42E+00	NA
As	µg L ⁻¹	3	1.30E+00	1.56E+00	NA
Ba	µg L ⁻¹	3	1.39E+01	1.70E+01	1.38E+01
Be	µg L ⁻¹	0	NA	NA	NA
Ca	µg L ⁻¹	3	2.14E+05	3.17E+05	3.83E+05
Cd	µg L ⁻¹	0	NA	NA	NA
Ce	µg L ⁻¹	0	NA	NA	NA
Co	µg L ⁻¹	2	3.92E-01	6.82E-01	3.21E-01
Cr	µg L ⁻¹	3	1.11E+00	4.08E+00	1.41E+00
Cu	µg L ⁻¹	2	5.51E+00	6.02E+00	3.42E+00
Dy	µg L ⁻¹	0	NA	NA	3.39E-03
Eu	µg L ⁻¹	1	3.42E-03	3.42E-03	4.73E-03
Fe	µg L ⁻¹	3	2.87E+00	2.99E+01	8.53E+02
Gd	µg L ⁻¹	0	NA	NA	NA
Hg	µg L ⁻¹	0	NA	NA	NA
K	µg L ⁻¹	3	2.74E+03	3.93E+03	4.01E+03
La	µg L ⁻¹	1	3.36E-03	3.36E-03	NA
Li	µg L ⁻¹	2	4.70E+01	4.85E+01	4.51E+01
Mg	µg L ⁻¹	2	7.95E+04	8.83E+04	1.08E+05
Mn	µg L ⁻¹	2	2.00E-01	2.53E-01	1.78E-01
Mo	µg L ⁻¹	2	2.25E+00	2.75E+00	2.49E+00
Na	µg L ⁻¹	3	7.83E+04	1.14E+05	1.62E+05
Nd	µg L ⁻¹	1	4.80E-03	4.80E-03	3.97E-02
Ni	µg L ⁻¹	2	7.17E+00	1.06E+01	6.23E+00
Pb	µg L ⁻¹	2	1.08E-01	1.91E-01	1.19E-01
Pr	µg L ⁻¹	0	NA	NA	NA
Sb	µg L ⁻¹	2	5.03E-02	4.10E-01	NA
Sc	µg L ⁻¹	1	3.53E+00	3.53E+00	4.68E+00
Se	µg L ⁻¹	0	NA	NA	NA
Sm	µg L ⁻¹	1	3.56E-03	3.56E-03	NA
Sn	µg L ⁻¹	0	NA	NA	NA
Sr	µg L ⁻¹	3	2.38E+03	2.86E+03	3.61E+03

Table continued on next page

Table 18. Range of Concentrations of Selected Inorganic Analytes in Drinking Water Samples Collected from Otis during 1998-2001 (Cont.)

Analyte	Unit	Otis			
		1998-2000			Concentration 2001
		^a N	^b Min	^c Max	
Th	µg L ⁻¹	2	1.19E-03	2.67E-02	NA
Ti	µg L ⁻¹	0	NA	NA	5.68E+00
Tl	µg L ⁻¹	0	NA	NA	NA
U	µg L ⁻¹	2	3.95E+00	4.20E+00	5.34E+00
V	µg L ⁻¹	3	1.10E+01	1.17E+01	1.14E+01
Zn	µg L ⁻¹	3	4.39E+00	1.16E+01	1.64E+01
Chloride	µg L ⁻¹	3	1.36E+05	3.86E+05	4.21E+05
Fluoride	µg L ⁻¹	3	1.29E+02	5.52E+02	7.53E+02
Nitrate	µg L ⁻¹	3	9.59E+03	2.20E+04	1.90E+04
Sulfate	µg L ⁻¹	3	3.27E+05	7.55E+05	7.56E+05

^aN = number of samples > MDL (1998-2000)^bMin = minimum measured concentration in annual samples from 1998-2000^cMax = maximum measured concentration in annual samples from 1998-2000^dNA = all samples below MDL for analyte

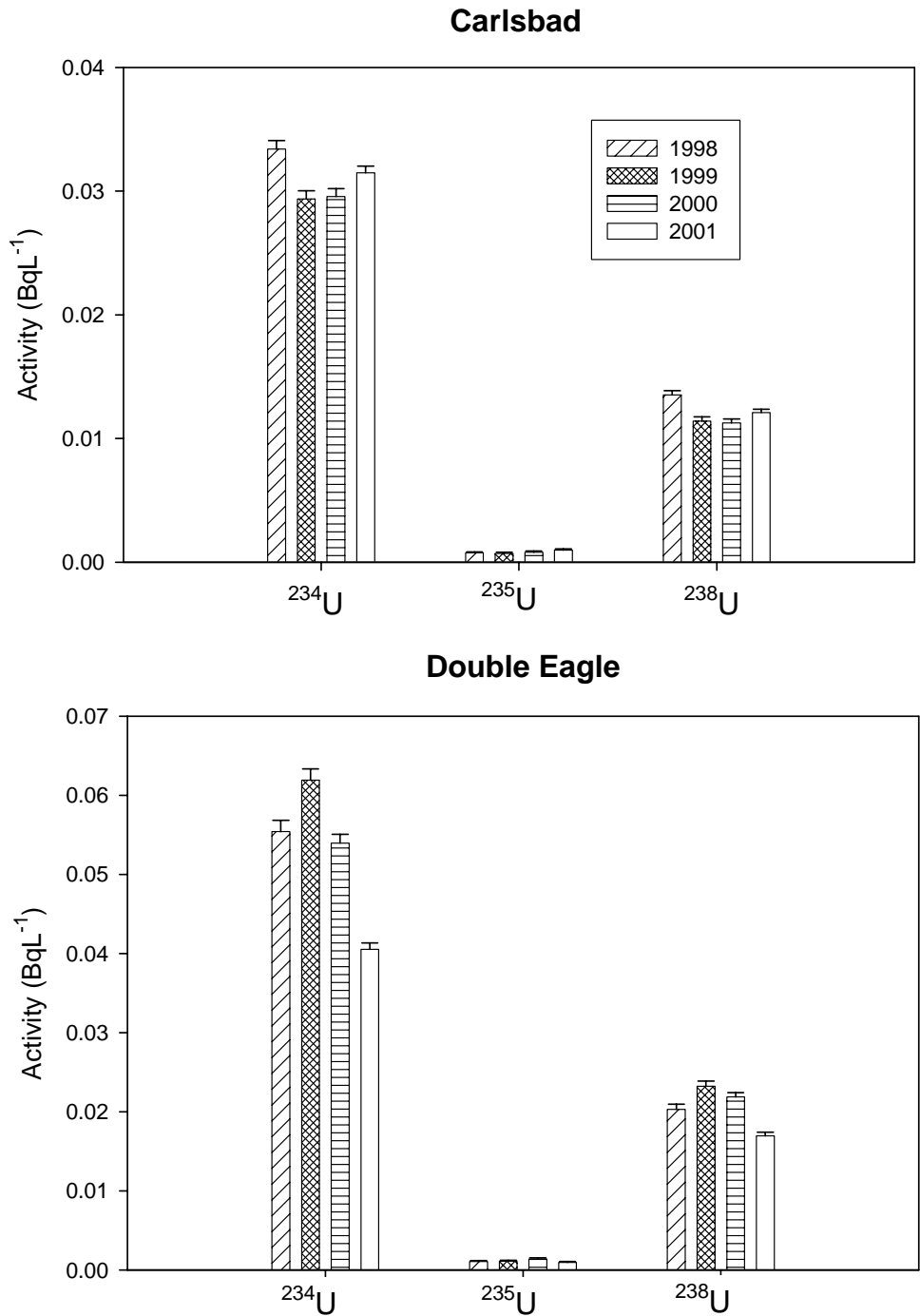


Figure 27. Activity Concentrations of Uranium Isotopes in Drinking Water Samples Collected at Carlsbad and Double Eagle during 1998-2001

Error bars represent the total radioanalytical uncertainty at 1 sigma.

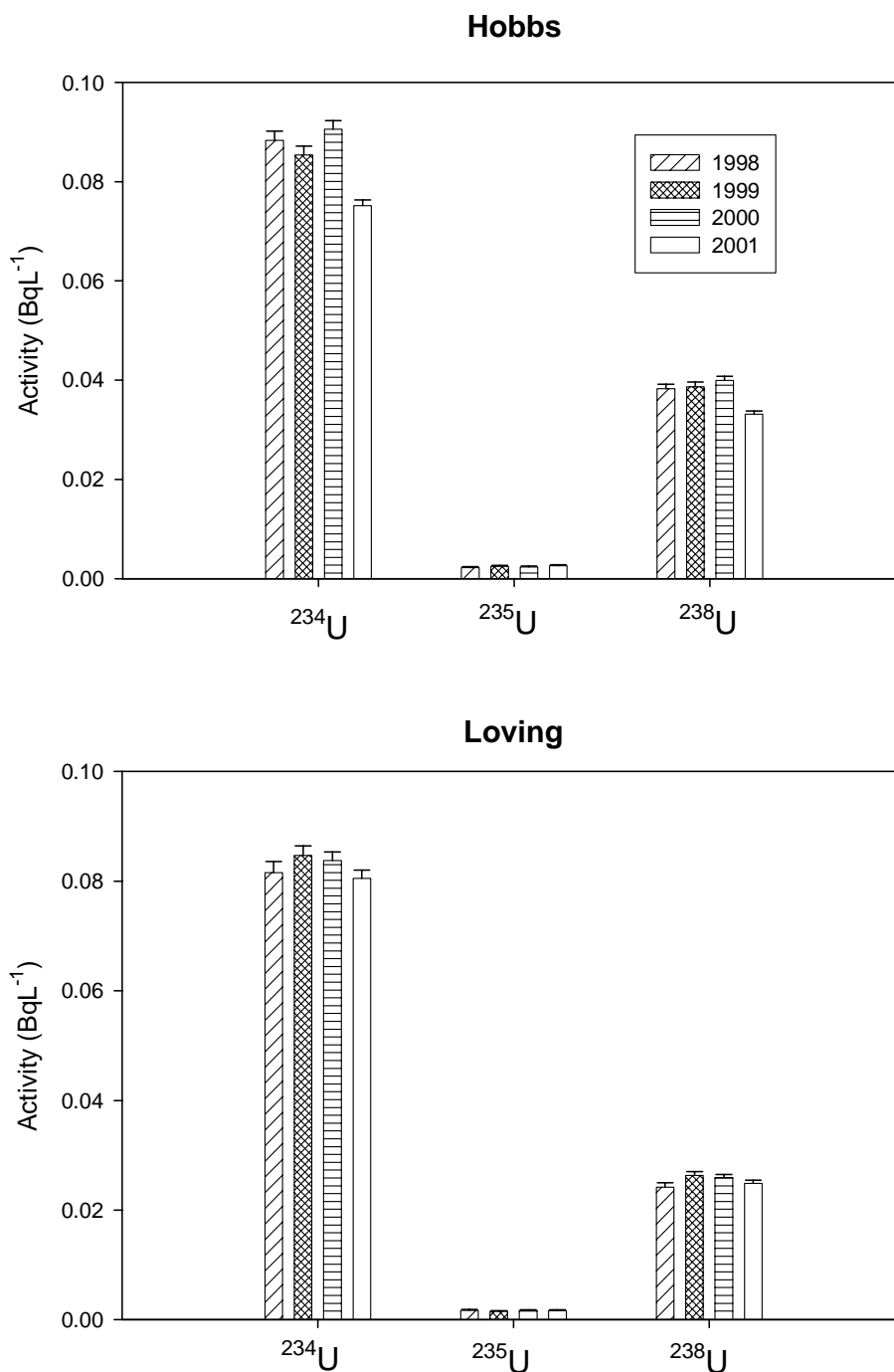


Figure 28. Activity Concentrations of Uranium Isotopes in Drinking Water Samples Collected at Hobbs and Loving during 1998-2001

Error bars represent the total radioanalytical uncertainty at 1 sigma.

Otis

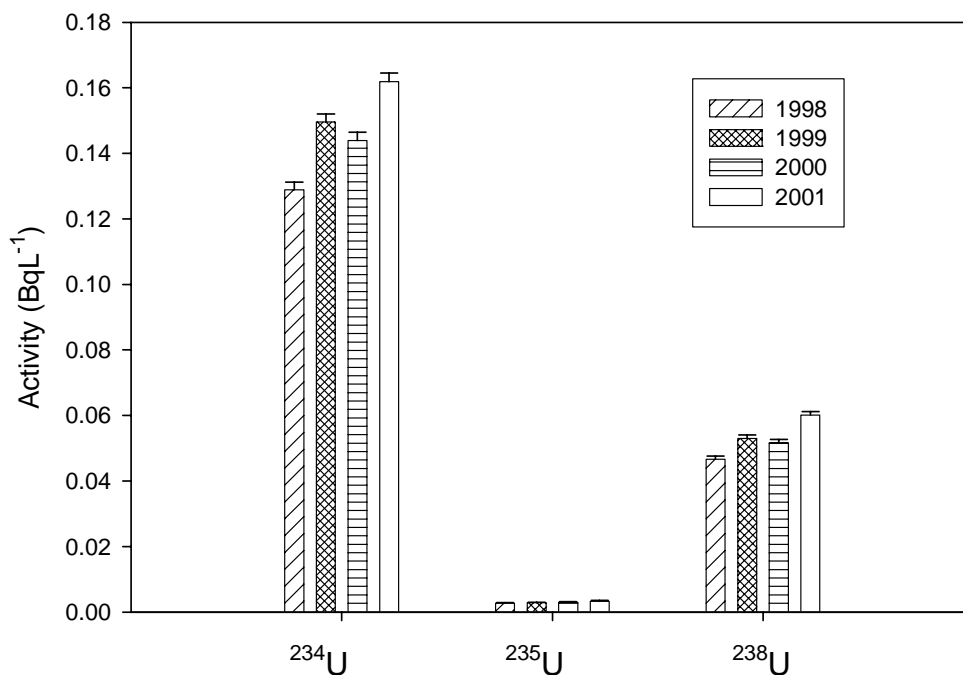


Figure 29. Activity Concentrations of Uranium Isotopes in Drinking Water Samples Collected at Otis during 1998-2001

Error bars represent the total radioanalytical uncertainty at 1 sigma.