

Prepared in cooperation with the National Park Service

# Concentrations of Elements in Sediments and Selective Fractions of Sediments, and in Natural Waters in Contact with Sediments From Lake Roosevelt, Washington, September 2004



Open-File Report 2006–1350

U.S. Department of the Interior  
U.S. Geological Survey

**Cover:** Photograph of Lake Roosevelt from near Hunters Point. (Photograph taken by Robert Drzymkowski, U.S. Geological Survey, September 2002.)

**Inset 1:** Deploying box corer. (Photograph taken by Greg Justin, U.S. Geological Survey, September 2004.)

**Inset 2:** Isolating core for incubation experiment. (Photograph taken by Greg Justin, U.S. Geological Survey, September 2004.)

**Inset 3:** Stirring of water overlying cores secured in incubator. (Photograph taken by Anthony Paulson, U.S. Geological Survey, September 2004.)

# **Concentrations of Elements in Sediments and Selective Fractions of Sediments, and in Natural Waters in Contact with Sediments From Lake Roosevelt, Washington, September 2004**

By Anthony J. Paulson, Richard J. Wagner, Richard F. Sanzolone, and Stephen E. Cox

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U.S. Geological Survey

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# Contents

Abstract.....	1
Introduction.....	1
Purpose and Scope .....	2
Methods.....	2
Sampling Methods.....	2
Incubation Experiments .....	6
Higher Energy Tumbling Experiments.....	7
Laboratory Methods.....	7
Total Digestion.....	7
Sequential Selective Extraction .....	7
Instrumental Analysis and Quality Assurance.....	8
Total Digestion.....	8
Sequential Selective Extraction .....	9
Water Samples.....	10
Concentrations of Elements in Sediment and Water .....	11
Sediment Samples .....	11
Total Digestion of Samples .....	11
Sequential Selective Extraction .....	11
Water Samples.....	11
Reservoir Water .....	12
Porewaters.....	12
Water Overlying Incubation Cores.....	12
Supernatants from Higher Energy Tumbling Experiment.....	12
Summary.....	13
References Cited.....	13

## Figures

Figure 1. Map showing sampling sites in Lake Roosevelt, Washington .....	3
Figure 2. Diagram showing core for incubation experiment after withdrawal of a time interval sample .....	6

## Tables

Table 1. Location and date and time of sampling sites in Lake Roosevelt, Washington, September 2004 .....	4
Table 2. Components of composite samples, types of replicate samples, and physical characteristics of sediments .....	4
Table 3. Quality-control data for analysis of sediments .....	15
Table 4. Interlaboratory comparison for analysis of arsenic, cadmium, copper, lead, and zinc in the composite samples .....	20
Table 5. Quality-control data for analysis of sequential selective extraction of sediments .....	21
Table 6. Analyses of field filtering blanks and results from submission of blind water reference standards .....	29
Table 7. Quality-assurance assessment of water samples .....	34
Table 8. Water samples identified as outliers .....	35
Table 9. Results of incubation control experiment .....	35
Table 10. Number of detections in sediments, selective extractants, reservoir waters, porewaters, incubation core samples, and supernatants of the tumbling experiments .....	38
Table 11. Concentrations of alkali and alkaline earth elements and non-metals in composite samples and field replicates .....	40
Table 12. Vertical and horizontal variation of concentrations of alkali and alkaline earth elements and non-metals .....	41
Table 13. Concentrations of metals in composite samples and field replicates .....	42
Table 14. Vertical and horizontal variation of concentrations of metals .....	44
Table 15. Concentrations of lanthanide and actinide elements in composite samples and field replicates .....	45
Table 16. Vertical and horizontal variation of concentrations of lanthanide and actinide elements .....	46

## Tables—Continued

Table 17. Concentrations of alkali, alkaline earth, non-metals, and actinide elements from selective extraction fractions of composite sediment samples .....	47
Table 18. Concentration of metals from selective extraction fractions of composite sediment samples .....	48
Table 19. Source of reservoir water, water column properties, and compositing data of porewater samples .....	50
Table 20. Concentrations of alkali and alkaline earth elements and non-metals in reservoir water from Lake Roosevelt.....	51
Table 21. Concentrations of metals in reservoir water from Lake Roosevelt .....	52
Table 22. Concentrations of lanthanide and actinide elements in reservoir water from Lake Roosevelt .....	53
Table 23. Concentrations of alkali and alkaline earth elements and non-metals in the porewater of Lake Roosevelt sediments .....	54
Table 24. Concentrations of metals in the porewater of Lake Roosevelt sediments.....	56
Table 25. Concentrations of lanthanide and actinide elements in the porewater of Lake Roosevelt sediments .....	58
Table 26. Description of incubation experiments using plastic acrylic core liners .....	60
Table 27. Concentrations of alkali and alkaline earth elements and non-metals in water from incubation experiments using sediment cores from Lake Roosevelt .....	61
Table 28. Concentrations of metals in water from incubation experiments using sediment cores from Lake Roosevelt.....	65
Table 29. Concentrations of lanthanide and actinide elements in water from incubation experiments using sediment cores from Lake Roosevelt .....	73
Table 30. Depth interval, weights of wet sediment, slurry, dry sediment, porewaters, and reservoir water during tumbling experiment .....	77
Table 31. Concentrations of alkali and alkaline elements and non-metals in supernatants from tumbling experiments using sediment cores and river sediment with slag from Lake Roosevelt .....	78
Table 32. Concentrations of metals in supernatants from tumbling experiments using sediment cores and river sediment with slag from Lake Roosevelt .....	80
Table 33. Concentrations of lanthanide and actinide elements in supernatants from tumbling experiments using sediment cores and river sediment with slag from Lake Roosevelt .....	82

## Conversion Factors, Datums, and Abbreviations and Acronyms

### Conversion Factors

Multiply	By	To obtain
centimeter (cm)	0.3937	inch
gram (g)	0.03527	ounce, avoirdupois
square kilometer (km <sup>2</sup> )	0.38611	square mile
kilogram per day	0.0010	metric ton per day
kilometer (km)	0.6214	mile
kilometer (km)	0.5400	mile, nautical
liter (L)	61.02	cubic inch
liter (L)	0.2642	gallon
liter (L)	33.82	ounce, fluid
liter (L)	2.113	pint
liter (L)	1.057	quart
milliliter (mL)	0.00026	milliliter
millimeter (mm)	0.03937	inch
meter (m)	1.094	yard (yd)
square centimeter (cm <sup>2</sup> )	0.1550	square inch
square meter (m <sup>2</sup> )	10.76	square foot

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$^{\circ}\text{F}=(1.8\times^{\circ}\text{C})+32$$

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$^{\circ}\text{C}=(^{\circ}\text{F}-32)/1.8$$

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L).

### Datums

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29).

Horizontal coordinate information is referenced to the North American Datum of 1927 (NAD27).

### Abbreviations and Acronyms

Abbreviation or acronym	Meaning
AAE	Alkali and alkaline earth
AVS	Acid volatile sulfide
CERC (USGS)	USGS Columbia Environmental Research Center
DI	de-ionized water
HPDE	high density polyethylene
IAEA	International Atomic Energy Association
ICP-MS	inductively coupled plasma-mass spectrometry
ILOD	instrumental limit of detection
L&A	lanthanide and actinide
LOI	loss on ignition
NIST	National Institute of Science and Technology
NRCC	National Research Council of Canada
RPD	relative percent difference
rpm	revolutions per minute
SRM	standard reference material
USGS	U.S. Geological Survey

# Concentrations of Elements in Sediments and Selective Fractions of Sediments, and in Natural Waters in Contact with Sediments From Lake Roosevelt, Washington, September 2004

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## Abstract

Twenty-eight composite and replicate sediment samples from 8 Lake Roosevelt sites were collected and analyzed for 10 alkali and alkaline earth elements, 2 non-metals, 20 metals, and 4 lanthanide and actinide elements. All elements were detected in all sediment samples except for silver (95 percent of the elements detected for 1,008 analyses), which was detected only in 4 samples. Sequential selective extraction procedures were performed on single composite samples from the eight sites. The percentage of detections for the 31 elements analyzed ranged from 76 percent for the first extraction fraction using a weak extractant to 93 percent for the four-acid dissolution of the sediments remaining after the third sequential selective extraction.

Water samples in various degrees of contact with the sediment were analyzed for 10 alkali and alkaline earth elements, 5 non-metals, 25 metals, and 16 lanthanide and actinide elements. The filtered water samples included 10 samples from the reservoir water column at 8 sites, 32 samples of porewater, 55 samples from reservoir water overlying sediments in 8 cores from the site incubated in a field laboratory, and 24 water samples that were filtered after being tumbled with sediments from 8 sites. Overall, the concentrations of only 37 percent of the 6,776 analyses of the 121 water samples were greater than the reporting limit. Selenium, bismuth, chromium, niobium, silver, and zirconium were not detected in any water samples. The percentage of concentrations for the water samples that were above the reporting limit ranged from 14 percent for the lanthanide and actinide elements to 77 percent for the alkali and alkaline earth elements. Concentrations were greater than reporting limits in only 23 percent of the analyses of reservoir water and 29 percent of the analyses of reservoir water overlying incubation cores. In contrast, 47 and 48 percent of the concentrations of porewater and water samples tumbled with sediments, respectively, were greater than the reporting limit.

## Introduction

The Lake Roosevelt National Recreation Area is heavily contaminated from trace elements discharged to the Columbia River from mining activities. A number of studies have reported elevated contaminant concentrations in Lake Roosevelt sediments (Johnson and others, 1990; Bortelson and others, 2001; Majewski and others, 2003; Cox and others, 2005) and in fish (Munn and others, 1995; EVS Consultants, 1998; Munn, 2000). In 1994, the U.S. Geological Survey (USGS) reported that concentrations of cadmium, copper, lead, mercury, and zinc in sediments were elevated to levels greater than biological impairment criteria in surficial sediments (Bortelson and others, 2001).

Lake Roosevelt was formed on the Columbia River by Grand Coulee Dam, which was constructed in the late 1930s and early 1940s to supply irrigation water, control flooding, and produce hydroelectric power. Lake Roosevelt is the largest reservoir by volume in Washington, and one of the largest in the Nation in total storage. Lake Roosevelt is in north-central Washington and extends 217 km upstream of the dam, to within 24 km of Canada. The surface area of the lake is 324 km<sup>2</sup>, with a full-pool elevation of 393 m. The stage level of the lake varies as much as 24 m annually due to operation of Grand Coulee Dam, with a mean annual water retention time of about 40 days, which varies substantially depending on reservoir management. The average depth is 36 m and maximum depth 114 m. Major tributaries include the Colville River, Kettle River, Spokane River, and Sanpoil River. Additional physical data describing Lake Roosevelt and the upper reach of the Columbia River in the United States are provided by Bortelson and others (2001).

The upper Columbia River and Lake Roosevelt are major recreational and economic resources that draw between 1 and 1.5 million visitors each year. A large attraction is the sport fishery, which includes walleye (*Stizostedion vitreum*), rainbow trout (*Oncorhynchus mykiss*), kokanee (*Oncorhynchus nerka*), yellow perch (*Perca flavescens*), and

smallmouth bass (*Micropterus dolomieu*), as described by McDowell and Griffith (1993). Contamination of fish from Lake Roosevelt was discovered in the early 1980s, when elevated concentrations of trace elements were found in fish collected from Lake Roosevelt near Grand Coulee Dam (Lowe and others, 1985). In a review of the literature, Serdar (1993) reported that several studies had documented elevated concentrations of trace elements, including mercury, in fish from Lake Roosevelt.

The elevated metal concentrations in Lake Roosevelt have been attributed to the transport of metallurgical waste and slag from a lead-zinc smelter in Trail, British Columbia, Canada (Bortleson and others, 2001). Since 1900, the smelter has discharged slag into the Columbia River at a rate of about 360 metric tons per day in recent years (Cominco Metals, 1991). In addition, decades of discharge of liquid effluent from the smelter in British Columbia contributed most of the zinc, lead, and cadmium detected in a recent sediment-coring study of Lake Roosevelt (Cox and others, 2005). Currently, the smelter discharges trace elements through its wastewater system. Other sources of trace elements in Lake Roosevelt include the Spokane River, which transports trace elements from mining areas around the Coeur d'Alene drainage (Yake, 1979), and additional historical mining activities in the region.

The 1992 sediment-quality assessment by Bortleson and others (2001) also included laboratory sediment bioassays. Lethal and sub-lethal effects were observed in laboratory toxicity tests with two aquatic organisms (*Hyaella azteca*, an amphipod, and *Ceriodaphnia dubia*, a water flea) exposed to bed sediments collected from near the International boundary and from some sites in Lake Roosevelt. The survival or reproduction of at least one, and commonly both, of the organisms was adversely affected by sediments collected from the free-flowing reach of the Columbia River entering Lake Roosevelt.

The bioavailability of metals in sediments has long been an issue in ecotoxicology (Luoma, 1983). Large differences in toxicity have been reported from sediments with similar metal concentrations but different physical or chemical parameters (for example, grain size, redox conditions, total and dissolved organic carbon, sulfide content, mineralogy, or hydrology). Early efforts to characterize metal availability in sediments were focused on applying a series of treatments with increasingly stronger chemical severity to the sediment prior to elemental analysis and quantification. This approach, referred to as sequential selective extraction, attempts to identify which and how much of particular metals are associated with particular sediment fractions, usually operationally defined by the treatments used. These approaches have been the subject of several reviews (Luoma, 1983; Tack and Verloo, 1995; Filgueiras and others, 2002).

## Purpose and Scope

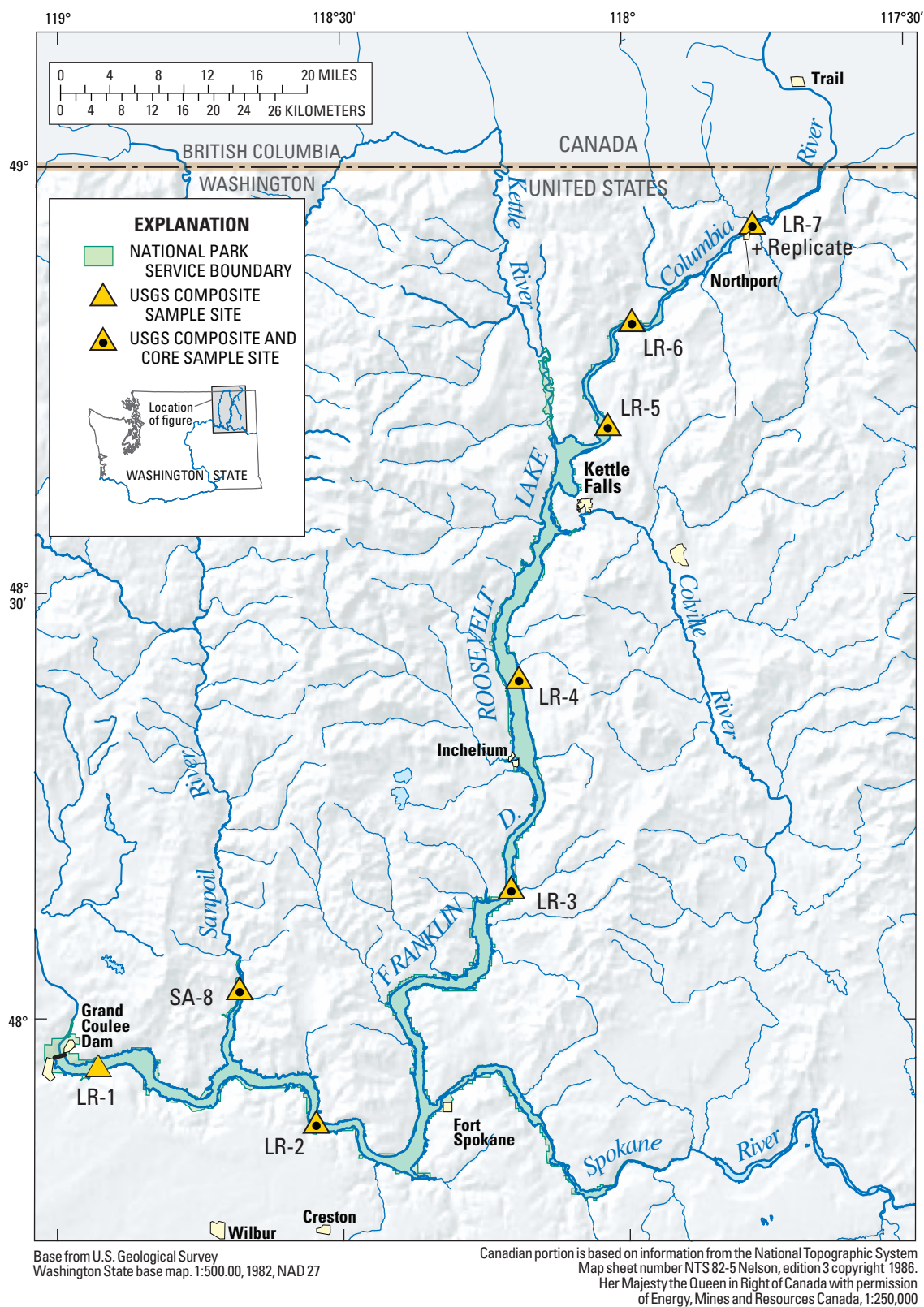
The purpose of this report is to present data about the elemental composition of sediments collected from Lake Roosevelt in September 2004, to evaluate the release of elements from the sediments after sequential selective extraction, and to determine the concentration of elements in filtered water after contact with the sediments. Several types of reservoir water (surface water, porewater, water incubated with sediments, and water tumbled with sediment) were analyzed for elemental concentrations.

## Methods

Sampling sites were spaced throughout the reservoir to capture the areal distribution of trace element concentrations in sediment from the inlet to the Grand Coulee Dam (fig. 1). In addition, one site with minimal influence from the downstream movement of slag material, on the Sanpoil River, was selected to serve as representative of background conditions. Large landslides of terrestrial material along the shoreline, cited as causing anomalies in the chemistry profiles of previous sediment cores on the lake (Cox and others, 2005), were clearly visible and were avoided during the site selection process. Operation of the dam can result in changes in water level within the reservoir by as much as 24 m annually, and dewatering has been demonstrated to affect the biogeochemical cycling of metals and suggested as a mechanism that controls the population and diversity of the benthic community (Bortleson and others, 2001). To minimize this potential effect, sediment sampling locations were selected only where water depths were greater than 12 m and had been permanently watered for the previous 2 years.

## Sampling Methods

One site per day (table 1) was sampled by boat between September 21 and 28, 2004, at water depths between 12 and 18 m using a 13.5 × 13.5 × 23-cm deep box corer, following the protocol for collection and processing described by the U.S. Environmental Protection Agency (2001). Four different types of sediment subsamples were collected at each site: (1) one 6.5-cm diameter sediment core (6.2 to 12.3 cm long) with intact overlying reservoir water for the sediment incubation experiments, (2) numerous 6.5-cm diameter plugs of the top 2 cm of sediment for extraction of porewater, (3) one 4.4-cm diameter core of up to 10 cm in length for evaluation of the vertical trends in elemental composition of the sediments, and (4) sediment within the top 10 cm taken from numerous



**Figure 1.** Sampling sites in Lake Roosevelt, Washington.

#### 4 Concentrations of Elements in Sediments from Lake Roosevelt, Washington, September 2004

**Table 1.** Location and date and time of sampling sites in Lake Roosevelt, Washington, September 2004.

Site identifier	Date	Time	Latitude	Longitude	Average depth (meters)
LR-1	09-21-04	16:00	47.942	-118.911	12.2
LR-2	09-24-04	13:30	47.883	-118.529	25.9
LR-3	09-23-04	12:50	48.155	-118.199	14.3
LR-4	09-25-04	11:40	48.394	-118.179	14.0
LR-4A	09-25-04	13:00	48.395	-118.179	29.9
LR-5	09-26-04	11:20	48.696	-118.022	12.8
LR-5A	09-26-04	16:00	48.681	-118.026	25.3
LR-6	09-27-04	12:10	48.819	-117.974	13.7
LR-7 <sup>1</sup>	09-28-04	14:00	48.923	-117.771	14.0
SA-8	09-22-04	17:20	48.036	-118.668	18.3
RM-743 <sup>2</sup>	09-13-02	11:45	48.971	-118.642	0

<sup>1</sup>Replicate sample LR7-R also collected.

<sup>2</sup>Unsorted riverine sediment with slag collected from a sand beach at river mile 743 near the International boundary as part of previous study (Cox and others, 2005).

box cores for the preparation of the large-volume composite sample (10 L). Sediment from the composite sample was used to analyze the grain-size distribution, loss on ignition (LOI) by heating to 450°C for 4 hours, the elemental composition of the solid sediments, and the elemental composition of three operationally defined solid fractions sequentially and selectively extracted from the sediments.

Some difficulties were experienced during sampling. For example at site LR-2, the corer was not closing properly when sampling at a depth of 13 m because gravel-sized sediments jammed the closing mechanism; and the site was moved to deeper water (about 26 m) for all sediment collection. Obtaining a sealed core for the incubation experiment was difficult because the box corer usually penetrated the sediments only 4 to 6 cm at water depths of 13 m and the reservoir water often leaked at the corners of the cores. The sandy texture of the sediments at LR-1 prevented the box corer from forming an intact seal, and no incubation core was obtained at this site. Alternative sites LR-4A (about 30 m) and LR-5A (about 25 m) that allowed greater penetration of the sampler (table 2) were sampled in order to collect intact cores for the incubation experiments. One porewater sample and one sediment sample were analyzed at these two alternative sites. The coarse texture of the sediment from site LR-2 at 13 m, which is within the elevation range of drawdown, probably is a result of winnowing of finer materials by wave action during the annual reservoir drawdown as the water surface of the reservoir dropped below the elevation from which sediments were taken.

**Table 2.** Components of composite samples, types of replicate samples, and physical characteristics of sediments.

[Replicate solid samples were either collected from sections (S) at the given depths or from the centrifuged sediments after extraction of porewaters (PW) with a PW designation letters A through F; multiple letter indicates compositing of samples from multiple cores (see tables 11–16. Abbreviations: LOI, loss on ignition; AVS, acid volatile sulfide;  $\mu\text{mol/g}$ , micromole per gram; cm, centimeter; –, not applicable; ND, not determined]

Site identifier	Sample type	Components of composite sample		Replicate solid samples	Physical characteristics (in percent)						Comments
		Number of cores	Average length of core (cm)		Sand	Silt	Clay	Moisture	LOI	AVS ( $\mu\text{mol/g}$ )	
LR-1	Composite	18	4	PW = B,C	82.0	14.6	3.4	27.2	0.70	0.04	Biofilm on top of coarse gravels.
LR-2	Composite	7	10	S = 0–1, 7–10	33.8	39.1	27.1	72.6	5.80	3.07	
LR-3	Composite	12	6	S = 0–1, 5–6	6.9	38.8	54.4	55.5	3.90	.55	
LR-4	Composite	14	4	PW = A,F	79.6	13.0	7.3	27.0	.50	.005	Biofilm over fine sand.
LR-4A	Incubation core	–	–		1.3	63.9	38.8	75.5	5.57	ND	
LR-5	Composite	15	4	PW = B,D	43.0	13.5	43.5	52.0	3.40	1.43	
LR-5A	Incubation core	–	–		50.6	40.9	8.5	60.3	3.47	ND	
LR-6	Composite	6	4	S = 0–1, 3–4	81.7	13.1	5.2	54.7	3.10	7.43	
LR-7	Composite <sup>1</sup>	10	4	PW = E,F	90.7	9.3	.0	26.3	.60	10.9	Coarse material.
SA-8	Composite	12	6	S = 0–1, 5–7	24.0	32.4	43.6	48.4	4.10	.40	

<sup>1</sup>Replicate sample LR-7-R also collected.

All plasticware (acrylic square and tubular core liners, styrene weighing pans, Teflon® spatulas, polypropylene spoons, beaker covers, centrifuge tubes and closures, all-plastic syringes, Teflon® syringe tips, and high-density polyethylene (HDPE) jars for sediments and bottles for water samples) for this study was cleaned with Liquinox®, rinsed with de-ionized water (DI), soaked in 5 percent trace-metal grade HCl, and rinsed with DI. Plasticware that came in contact with water samples analyzed for aqueous elemental concentrations was additionally soaked in 4 N trace-metal grade HNO<sub>3</sub>, rinsed with DI water, rinsed with 0.16 N Optima HNO<sub>3</sub>, rinsed with DI water, and dried in a laminar flow hood. The lot of acid-cleaned 25-mm Millex Durapore® in-line filters was pre-tested for contamination with the acid-cleaned, all-plastic syringes before executing the field sampling, and all results were acceptable.

Upon bringing the box corer onboard with a sealed core, a tubular 6.5-cm diameter acrylic core liner was inserted into the middle of the 13.5 × 13.5-cm box-core liner in a manner in which the intact reservoir water was preserved. The water outside of the inner acrylic core liner was siphoned off and the remainder of the sediments in the box core outside the acrylic core liner was then removed to the compositing bowl. The bottom of the acrylic core was then sealed with Parafilm® held by a rubber cap. The gritty nature of the slag material collected at site LR-7 caused it to break through the Parafilm® seal and required that the incubation core liner be pre-sealed. Duplicate sediment samples from site LR-7 were collected in two 4.4-cm diameter core liners from two different box cores (LR-7 and LR-7R), which were then carefully inserted into the larger 6.5-cm diameter pre-sealed incubation core liners. After the smaller core liners were removed and the sediment settled, the larger core liners were each filled with different samples of surface water from the site. The tops of incubation core liners were sealed with Teflon® tape and polypropylene beaker covers that contained a center hole for the stirrer and two small holes for Teflon® syringe tips. The tops of the sealed cores were wrapped in Parafilm® and the cores were carefully placed in a carrying caddy in a cooler that was packed with ice for transport to the USGS field laboratory at Fort Spokane, Wash., where core incubation experiments began within 8 hours and continued for about a month.

Sediment for porewater extraction was obtained by inserting 4.4-cm diameter core liner into the middle of the box core to the bottom for core samples that were 4 to 6 cm long. After any reservoir water that had not leaked from the corners of the box core was siphoned off, sediment around the tubular core liner was moved aside. The 4.4-cm diameter plug of sediment was excavated by sliding a thin styrene tray under the core liner and removing the core liner containing the sediment plug from the box core. The tubular core liner was removed from the tray, and the top 2 cm of the sediment plug was packed into a 50-mL polypropylene centrifuge tube

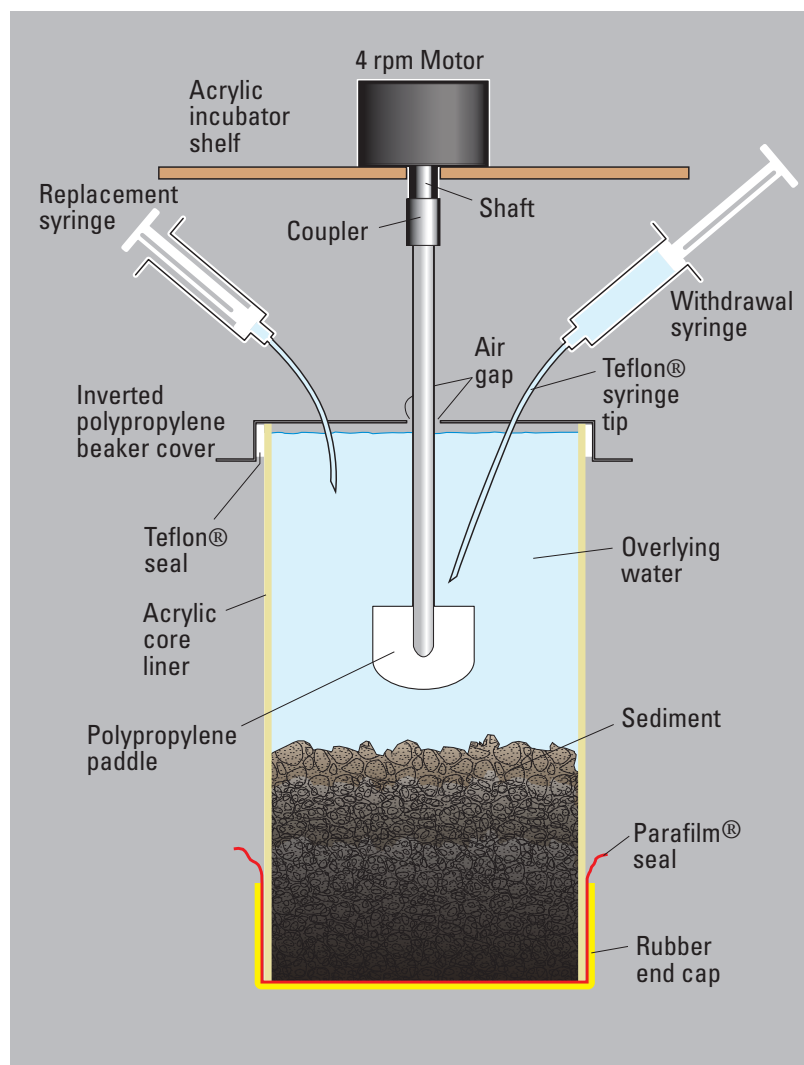
with a polypropylene spoon. Precautions to prevent sediment contact with atmospheric oxygen were not taken because the sediments had already been exposed when reservoir water leaked out of the poorly sealed box corer. After sealing the centrifuge tube closure with Parafilm®, centrifuge tubes from multiple box cores were double sealed in plastic bags and transported to the field laboratory on ice. Within 8 hours, the sediment was centrifuged at 2,000 revolutions per minute (rpm) for 20 min. Within a portable laminar flow hood, the supernatant in the centrifuge tube was withdrawn from the centrifuge tube into an all-plastic syringe, filtered through a 25-mm 0.22-μm pore size Millex Durapore® in-line filter into a 30-mL HDPE bottle, and preserved to a concentration of 0.16 N Optima HNO<sub>3</sub>. If sufficient water was extracted (a minimum of 6 mL), porewater from individual cores was analyzed. Otherwise, water from multiple cores was composited before analyses. Water from each site was collected either from a draining or sealed box corer, or from the surface of the water column (sites LR-5A and LR-7), filtered, preserved, and stored in a HDPE bottle to compare to porewater concentrations. Additional reservoir water was collected either from sealed box cores, draining box cores, or surface water in 500-mL HDPE bottles to replace water withdrawn for sample analysis during the incubation experiments, as described later in this report.

At sites LR-2, LR-3, LR-6, and SA-8, a second core was collected that was sufficiently long to warrant collecting sections of a vertical core. A 4.4-cm diameter core liner was inserted into the middle of the box core and all reservoir water was siphoned off. All sediment to a depth of 10 cm around the tubular core liner was added to the composite bowl. Parafilm® on an aluminum plate was slid under the tubular core liner and the assembly was placed on an extruder piston. The plate was removed and the sediment was sealed onto the piston by the Parafilm®. The core liner was manually moved down the piston in 1-cm increments, which exposed vertical core sections of sediments that were placed into plastic bags. One-cm sections from deeper sections of the cores at sites LR-2 (7-10 cm), LR-3 (5-6 cm), and LR-6 (3-4 cm), were combined before elemental analysis. Likewise, 1-cm sections (5-7 cm) of a longer-than-average core (7 cm) from SA-8 were combined. The sediment remaining in the centrifuge tubes from 0-2 cm samples after the extraction of porewater was analyzed for elemental composition to assess variability in elemental composition of sediments at sites LR-1, LR-4, LR-5, and LR-7, where the box core only penetrated about 4 cm.

Sediment from multiple box cores (between 6 and 18 cores) was required to obtain 10 L of sediment to prepare the composite sample for toxicity testing by the USGS Columbia Environmental Research Center (CERC) laboratory in Columbia, Mo. (table 2). After examination by archaeologists for cultural resources using plastic utensils, sediment outside of the tubular core liners used to collect incubation cores,

porewater samples, and vertical sections (to a depth of 10 cm) or sediment from the entire surface area of the box core to a depth of 10 cm was added to the compositing bowl. After a sufficient volume of sediment was collected, the composite was manually mixed for about 60 seconds. Aliquots from the compositing bowl were placed in a 500-mL HDPE wide-mouth bottle for elemental analysis and a 200-mL polypropylene jar for sequential selective extraction. A replicate composite sample (LR-7R) was collected at site LR-7 from additional box-core samples. Aliquots of the composite samples for elemental composition were shipped to the USGS

Minerals Laboratory in Denver, Colo. Samples for analysis by sequential selective extraction were first shipped to the USGS Water Science Center in Austin, Tex. for freeze drying, and were then shipped to the USGS Minerals Laboratory for later analysis. Aliquots of composite samples (two 3.79-L low-density polyethylene jugs) for analysis of grain size, loss on ignition, acid volatile sulfide (AVS), and sediment composition of selective elements were transported on ice first to the field laboratory, refrigerated at the field laboratory until the field exercise was completed, then shipped on ice to the USGS CERC laboratory.



**Figure 2.** Core for incubation experiment after withdrawal of a time interval sample.

## Incubation Experiments

Incubation experiments were designed to simulate potential release of aqueous elements under lake-like conditions. Upon returning to the field laboratory at Fort Spokane, Wash., each evening, the incubation core was placed in a holder in one of two incubators set at the temperature of the bottom reservoir water (approximately 18° C for sites LR-2, LR-3, LR-4A, and SA-8; and approximately 14° C for LR-5A, LR-6, LR-7, and LR-7R). The polypropylene beaker cover was removed and site water was added to fill the core to the top. The rod of a polypropylene paddle was inserted through the center hole of the cover (leaving a gap less than 1 mm). The cover was resealed with Teflon® tape in a manner that positioned the paddle in the middle of the overlying water (fig. 2). The rod end of the paddle was attached to a motor set at 4 rpm, which was run continuously for the duration of the experiment. Two Teflon® syringe tips attached to all-plastic syringes were inserted to the depth of the paddle through press-fit holes. After about an hour, an 11-mL sample was withdrawn from the overlying water with the withdrawal syringe and filtered through a 25-mm 0.22- $\mu$ m Millex Durapore® in-line filter into a 15-mL HDPE bottle under the confines of a laminar flow hood and preserved to a final concentration of 0.16 N Optima HNO<sub>3</sub>. After the withdrawal syringe was placed back on its tip, the replacement syringe was removed from the second inserted tip and filled with 11 mL of site water to replace the first 11-mL aliquot. The 11 mL of replacement water was then slowly added to the overlying water. This removal and replacement process was repeated

at intervals of 2 and 4 days, and approximately 8, 16, and 32 days, with a duplicate sample being taken at approximately 16 days. In addition to the small gap between the cover and the stirring rod, the overlying water was in contact with the atmosphere only during portions of the 15 minutes required to process a sample through the 10-cm-long syringe tip.

At the end of the month-long incubation experiment (November 3, 2004), the reservoir water in each core was siphoned into a receptacle to measure the volume and pH. Each sediment core was then placed on an extruder, the bottom rubber cap cut away, and the top 2 cm was extruded into a 125-mL wide-mouth HDPE bottle and transported on ice to the USGS Washington Water Science Center, Field Service Unit in Lakewood, Wash., for the higher energy tumbling experiment. The lower portions of each core were placed in polypropylene jars, frozen, and transported to the USGS CERC laboratory for analysis of dissolved organic carbon in the porewaters.

## Higher Energy Tumbling Experiments

The extent of release of metals from sediments is partially determined by the extent of mixing of water and sediments. The physical configuration of incubation cores and the slow speed of the paddle in the incubation experiment provided a low level of physical interaction between sediments and water, similar to a lake environment. The sediment from the top 2 cm from each incubation core was further exposed to water under a higher energy tumbling experiment, similar to a higher energy riverine environment. Approximately 30 mL of site water was added to each pre-weighed 125-mL wide-mouth HDPE bottle containing the sediment and the bottle was reweighed. In addition, gritty sediment at the bottom of incubation cores LR-5A (4.7-6.2 cm) and LR-6 (4.2 and 5.2 cm) also were tumbled with site water. Two samples of approximately 150 grams of river sediment with slag collected by Cox and others (2005), and labeled as RM 743 also were tumbled with approximately 80 mL of LR-7 site water. The bottles containing the slurries were sealed and attached to a vertical 1-m wheel attached to a motor, which caused the bottles to be turned end over end seven times a minute. After 15 minutes, the wheel was stopped and the slurry was allowed to settle. Within a laminar flow hood, 11 mL of supernatant was withdrawn, filtered through a 25-mm 0.22- $\mu$ m Millex Durapore® in-line filter into 15-mL HDPE bottles and preserved to a final concentration of 0.16 N Optima  $\text{HNO}_3$ . The 125-mL bottles were placed on the rotating wheel for 43 days, at which time the samples were taken off the wheel and allowed to settle for one day before the supernatant was filtered, and preserved. The 125-mL bottles were then placed in an oven and the sediment dried at 105°C to obtain the mass

of the dry sediment and the percent moisture of the original sediment in the top 2 cm of the 6.5-cm diameter core, and the water:sediment ratio of each slurry.

## Laboratory Methods

### Total Digestion

Upon arrival at the USGS Minerals Laboratory in Denver, Colo., the aliquots from the composite samples, vertical sections, and sediments from the extraction of porewaters were oven-dried (table 2). The sediments were then digested using hydrochloric, nitric, perchloric, and hydrofluoric acids (lab code T20 as described in Briggs and Meier, 2002). This digestion procedure is not suitable for refractory elements. Laboratory quality-assurance procedures included digestion of the standard reference material (SRM) MAG-1 (duplicate), National Institute of Science and Technology (NIST) 2704, and SCO-1 and analysis of the digestion solution. A duplicate of standard National Research Council of Canada (NRCC) PACS-2 and the standard International Atomic Energy Association (IAEA) -405 were submitted as field samples. In addition, the total digestion of the eight composite samples using the four-acid digestion was compared to the strong-acid digestion used by the USGS CERC laboratory.

### Sequential Selective Extraction

The sequential selective extractions procedure partitioned the trace elements within the sample into four operationally defined fractions that have been related to the bioavailability and mobility of elements. Discussion and assessment of sequential selective extraction techniques are summarized by Tessier and others (1979) and Chao (1984). Sequential selective extraction procedures of the composite sediment samples followed those of the European Commission of Standards, Measurements, and Testing (Rauret and others, 2001) and were evaluated by comparison to results of sequential selective extraction of the freshwater reference sediment BCR-701. The first fraction of the sequential selective extraction is presumed to contain elements weakly sorbed to the surface of sediment particles and elements associated with carbonate coatings. The second fraction contains elements associated with iron and manganese oxide coatings on the surface of sediment grains. The third fraction contains elements associated with organic matter and sulfide mineral coatings phases. Solid material remaining after the three extraction treatments is considered the recalcitrant residual material consisting largely of independent mineral grains.

Aliquots of the composite samples from each of the eight sites for analyses of sequential selective extracts were freeze-dried in Austin, Tex., beginning on October 1, 2004. The frozen samples were placed in a Labconco Freeze drier with condenser temperature of less than  $-40^{\circ}\text{C}$ . The atmosphere in the freeze-drier was evacuated to facilitate sublimation of the ice from the sediment-ice mixture. Samples were held in the freeze-drier for 4 days to complete the drying process. During the second, third and fourth days, progressive warming of the evacuated chamber up to  $60^{\circ}\text{C}$  was applied to facilitate drying. When completely dry, the sediment samples were resealed in their original containers and forwarded to the USGS Minerals Laboratory for analysis.

A four-step sequential selective extraction procedure was performed on the aliquots of each of the composite sediment samples from the eight sites and the standard reference material BCR-701 in January 2005 at the USGS Minerals Laboratory. As part of the laboratory quality assurance, a process blank and wash blank were analyzed to assess bias and two pairs of duplicate sediment samples were used to assess variability in the trace-element concentration data for each step of the sequential selective extraction process. The process blank consisted of processing the appropriate reagent for each of the four steps through the extraction procedure in the absence of sediment. Following each step of the sequential selective extraction, the extract fraction was washed with DI water and the wash solution of each sample was composited to provide an average wash blank to quantify the amount of metals potentially lost during the rinsing process of each step. One of the duplicate pairs was the standard reference material BCR-701, for which certified concentrations of cadmium, chromium, copper, lead, nickel, and zinc have been determined for the sequential selective extraction procedures used in this study. The other sediment sample used for duplicate analysis was the aliquot from the composite sample from site LR-5.

For fraction 1, 40 mL of 0.11 M acetic acid was added to an acid-cleaned polypropylene centrifuge tube containing 1 g of sediment and the tube was shaken on a Fisher Scientific mechanical rotator, set at 18 rpm for  $16 \pm 0.5$  hours at  $23^{\circ}\text{C}$ . After centrifuging for 20 minutes at 15,000 rpm, the supernatant was decanted into an acid-cleaned polypropylene centrifuge tube and refrigerated until analysis by inductively coupled plasma-mass spectrometry (ICP-MS) within 10 days. The sediments were washed with 20 mL of DI water by shaking for 15 minutes in a centrifuge tube, the tube was centrifuged for 20 minutes at 15,000 rpm, and the supernatant decanted into an acid-cleaned polypropylene centrifuge tube for wash-blank analysis. Additionally, a process blank was prepared by submitting DI water to all processes of the fraction 1 extraction.

For fraction 2, 40 mL of 0.5 M hydroxylamine hydrochloride was added to the tube containing the washed sediment remaining after the procedure for fraction 1. The

sediment then was shaken for 16 hours at  $23^{\circ}\text{C}$ . The slurry was then centrifuged, the supernatant decanted into a separate bottle, and the sediments were then washed as in procedure for fraction 1 for a fraction 2 wash blank. A process blank also was prepared for fraction 2.

For fraction 3, the washed sediment remaining after removing fraction 2 was digested in 10 mL of 8.8 M  $\text{H}_2\text{O}_2$  and stabilized to pH 2-3 for 1 hour at  $22^{\circ}\text{C}$ . The digestion was continued for another hour at  $85^{\circ}\text{C}$ , allowing evaporation to decrease the volume to 3 mL. Another 10 mL of  $\text{H}_2\text{O}_2$  was added to the sediment and digested for a third hour at  $85^{\circ}\text{C}$ , allowing the volume to decrease to 1 mL during the last 30 minutes. Fifty mL of DI water was added to the centrifuge tube, which was then shaken for 16 hours at  $22^{\circ}\text{C}$ . After centrifugation, the supernatant was decanted into a separate bottle, and preserved to a concentration of 0.16 N  $\text{HNO}_3$  (pH of 2). The residual sediment was then washed as in the procedure for fraction 1 for a wash blank. A process blank also was prepared for fraction 3.

For fraction 4, the residual sediment was transferred to a Teflon® beaker for digestion of the residual fraction using a four-acid mixture of HCl,  $\text{HNO}_3$ , HF, and  $\text{HClO}_4$ . A process blank was also prepared for fraction 4. In some instances, the transfer of residual sediment from the extraction vessel to the Teflon® digestion beakers was incomplete with small amounts of residual sediment adhering to the 50 mL centrifuge tube used during the extraction procedure.

## Instrumental Analysis and Quality Assurance

### Total Digestion

The four-acid digestion solutions of the sediment samples, laboratory controls, and blind SRMs were analyzed by ICP-MS on an Elan 6000 with dwell times between 3 and 50 milliseconds (Lab code T20 described in Briggs and Meier, 2002) at the USGS Minerals Laboratory. The ICP-MS was calibrated to a 0.16 N  $\text{HNO}_3$  acid-blank solution and two multi-element standard solutions to cover the mass range and generate the mass response. Laboratory quality assurance included analysis of wash water, duplicate analyses of LR-1 composite at the beginning and at the end of the run, duplicate analyses of LR-1 in sequence at the end of the run, analysis of SRMs NIST 2704, SCO-1, and duplicate analyses of SRM MAG-1 during the run. In addition, PACS-2 (analyzed in duplicate) and IAEA-405 were submitted from the field as blind samples. The relative percent difference (RPD) for analyses of the LR-1 composite and MAG-1 generally was less than 10 percent except for antimony, beryllium, cerium, lanthanum, molybdenum, scandium, selenium, thorium, titanium, and uranium (table 3; at back of report).

The average percent difference of laboratory controls MAG-1, NIST 2704, and SCO-1 from the assumed true values suggested by Potts and others (1992) generally were less than 10 percent except for chromium (+10.8 percent), molybdenum (-29.5 percent), thallium (+17.4 percent), titanium (-14.0 percent), and yttrium (-13.6 percent). Average results of the analyses of the SRM PACS-2, submitted blind from the field, were within 10 percent of all certified values, except for uranium (-23.3 percent), and results for the single analysis of the IAEA-405 SRM differed from the certified value for a number of elements: antimony (-22.7 percent), chromium (+11.1 percent), lanthanum (-17.3 percent), lithium (+16.5 percent), and strontium (+23.7 percent). Analysis of field duplicates from LR-7 generally resulted in RPDs of less than 10 percent except for beryllium (11.8 percent), bismuth (47.1 percent), cadmium (15.4 percent), and thorium (17.7 percent). The concentrations and RPDs of the major elements and transition elements by the four-acid digestion generally were within acceptable ranges. Significant variations and deviations from certified or suggested values were found for the lanthanide and actinides elements and the results for these elements are provided for informational purposes only. There were considerable differences in the elemental concentrations of arsenic, cadmium, copper, lead, and zinc between the method using the four-acid digestion and analysis by the USGS Minerals Laboratory and the method using the strong-acid digestion and analysis of a different aliquot of the composite sample by the USGS CERC laboratory ([table 4](#); at back of report). A four-acid digestion extracts more material phases than the strong-acid digestion, especially silicate-lattice minerals, which could explain the lower values obtained by the strong-acid digestion, especially for lead. The higher values returned by the strong-acid digestion were most likely a result of actual differences in the two aliquots taken from the composite sample due to its heterogeneity resulting from the coarse nature of the composite samples, such as the coarser material analyzed from site LR-7.

## Sequential Selective Extraction

Calibration standards for the analyses of elements in leachates from fractions 1 and 2 of the sequential selective extraction were prepared in 0.11 M acetic acid and 0.5 M hydroxylamine hydrochloride, respectively, and both standards and samples were diluted 1:10 before analyses. The elemental concentrations in the wash blanks were less than the instrumental limit of detection (ILOD) or insignificant. The concentrations of the elements detected in the process blank water ([table 5](#), at back of report) were near analytical reporting limits and typically less than 1 percent of the concentrations determined for the environmental samples, and

thus generally not a significant source of bias in the sample data. The greatest degree of bias was found for chromium, for which the concentrations of seven samples were within twice the process blank for fraction 1 (0.3 µg/g), and for which concentrations of eight samples were within three times the process blank for fraction 3 (2.3 µg/g). Therefore, Cr concentrations for fraction 1 and 3 are rated as estimated. Lead was detected in the process blank of fraction 1 of the sequential selective extraction at 0.01 µg/g and of fraction 2 of the sequential selective extraction at 0.04 µg/g. Lead concentrations in process blank samples were less than 1 percent of reported sample concentrations in all instances, except for three samples of the first fraction where the process blank concentrations were less than 4 percent of the reported sample concentrations. Magnesium was detected in some process blanks at concentrations ranging from 2.4 to 5.5 µg/g; in all instances magnesium present in process blank samples was less than 1 percent of sample concentrations. The process blank for the analysis of residual sediment (fraction 4) contained concentrations of aluminum, barium, copper, gallium, lead, magnesium, potassium, rubidium, strontium, and zinc; all concentrations except copper were much less than 1 percent of reported concentrations. Copper was present in the process blank of fraction 4 at 0.2 µg/g, which was equivalent to about 3 percent of the lowest concentrations of the environmental samples.

Variability in the first three steps of the sequential selective extraction process was assessed by comparison of the concentrations measured in this study to the reported certified concentrations of cadmium, chromium, copper, lead, nickel, and zinc in the standard reference material BCR-701. These data ([table 5](#)) show that, except for the cadmium and lead determinations in fraction 3 and the lead determinations in fraction 1, recovery of the expected concentration typically was within 10 percent of the certified value; although concentrations had a slight tendency to be lower than expected (average recovery was 93 percent). In fraction 3 of the extraction process, the measured lead concentrations were only 50 percent of the certified values. Because the average percent differences from the certified value for the duplicate samples was 49.5 percent, the reported lead concentration data for fraction 3 in the extraction process also is likely to be biased low by a significant amount. Low recovery of lead in fraction 3 of the sequential selective extraction process, on the order of 50 percent, also was noted by Rauret and others (2001) in the concentration data used to obtain the certified concentrations.

Variability in the sample data set was assessed by the comparison of results from duplicate analysis of the same sample. Variability in duplicate samples from the sequential selective extractions typically was less than 10 percent.

Variability, as measured by relative percent difference in concentrations determined on the residual sediment, following the sequential selective extraction however, was quite large, as much as 91.5 percent with an average of about 50 percent. Variability increased for the procedures for the subsequent fractions in the sequential selective extraction process. Average variability in relative percent differences in step 1 were about 3 percent, increasing to about 4 percent the second step and more than 5 percent in the third step.

## Water Samples

Site water, porewaters, overlying water of the incubation cores, and supernatants from the tumbling experiment were diluted by a factor of 5 with 0.16 N HNO<sub>3</sub> before analysis by ICP-MS on a Perkin-Elmer Elan 6000 with 35 sweeps in the peak-hopping mode, with dwell times ranging from 10 to 100 milliseconds. The instrument was calibrated with standards prepared in 0.16 N HNO<sub>3</sub> (Lab codes T21 and T23 in Lamothe and others, 2002). Internal standards (500 µg/L lithium-6, 20 µg/L rhodium, and 10 µg/L iridium) were mixed in a 1:1 ratio with samples using a dual-channel peristaltic pump equipped with a mixing manifold and coil. The isotopes used to measure elemental concentrations were selected to minimize isobaric overlap from other elements, and internal calculations correct for isobaric interferences for arsenic, cadmium, dysprosium, gadolinium, germanium, iron, molybdenum, tungsten, selenium, and vanadium. Laboratory quality-control samples that are not included in this report include analysis of solution blanks, duplicates, and NIST SRMs 1640 and 1643d. Field quality-control samples included analysis of field-laboratory filtering blanks, duplicates of the incubation samples at about 16 days, and eight samples of five reference samples standards (NRCC SLRS-3, USGS Standard Reference Sample T-171 and T-179, and NIST 1640 and 1643e).

The average concentration of only manganese in the DI water-filter blanks (after passing through pre-cleaned in-line filters) was greater than the ILOD and the reporting limit for manganese was adjusted to 5 µg/L, based on 3 times the standard deviation of concentration of the field laboratory filter blanks (table 6; at back of report). ILODs are calculated based on the variation of the instrumental signal and could be a result of a number of factors, including polyatomic interferences, impurities in reagents, or random contamination in the laboratory or field.

The decision to increase the reporting limit by a factor of 5 times the ILOD to account for the 5-fold dilution of samples prior to analyses was based on: (1) the replication and recovery of the double blind standards as a function of increasing concentration, (2) the replication of field duplicates as a function of increasing concentration, (3) the internal

consistency of temporal trends in the incubation samples, and (4) the amount of data with concentrations between 1 and 5 times the ILOD. The reporting limits of all elements for which SRM data were available were increased by a factor of 5, except for antimony, arsenic, copper, molybdenum, nickel, and sodium (table 7; at back of report).

The recovery of copper in the low-concentration SRM NRCC SLRS-3 was low (57 percent), and the RPD of the nickel analysis was 50 percent. Additionally, recovery of magnesium in SLRS-3 was very low (42 percent) and recovery of manganese was very high (260 percent). Concentrations of all elements for which there were no reported SRM values for these five standards are provided for ancillary information purpose only. The original ILOD was accepted if the RPD at concentrations near the ILOD were low. If the RPDs for duplicates at concentrations between 1 and 5 times the ILOD were unacceptable or inconsistent, the reporting limit was increased by a factor of 5. The assessment of the quality-control data for each element is provided in table 7. The results for single elements from various samples were flagged as outliers in the results tables and the disregarded values are provided in table 8 (at back of report). In addition, the major cation data from one of the duplicate samples from the LR-5A incubation core at about 19 days (LR-5AINC19A) was inconsistent with the major ion data from other samples of the overlying water and the results from the entire sample were disregarded.

The uptake or release of elements by the apparatus for the incubation experiments was tested by running a control experiment (no sediment) containing site water from the lower reservoir held in a pre-sealed core liner with the stirring paddle and syringe tips inserted through the sealed cover. Triplicate samples were withdrawn and filtered after 1 hour and after 34 days. The concentration of alkali and alkaline earth elements and silica increased within a narrow range between 20 and 33 percent (table 9; at back of report), but these concentrations were statistically the same (*p* values between 0.07 and 0.32). For example, concentrations of magnesium increased from  $5.0 \pm 0.1$  mg/L to  $6.0 \pm 1.1$  mg/L. The consistent increase over the 34 days may have been a result of evaporation within the incubator and loss of water vapor through the 1 mm gap between the cover and the rod of the stirring paddle. The low concentrations of aluminum and antimony at the beginning of the control test did not increase beyond the precision of the analyses (approximately 10 percent). At the end of the control experiment, copper was detected in one sample at the reporting limit and in one sample at twice the reporting limit in one sample. At the end of the control experiment, the average zinc concentration was 3.3 µg/L and the reporting level for zinc values for only the incubation experiments was set at 3.3 µg/L.

## Concentrations of Elements in Sediment and Water

Samples were collected from 8 sites in Lake Roosevelt and analyzed for elemental concentrations in 28 samples of sediments, 32 samples of extracts from sequential selective extractions, and for samples of site water from 10 reservoir water samples, 32 porewater samples, 55 samples of reservoir water overlying incubation cores, and leachates from 24 higher energy tumbling experiments. Results for sediment and water samples are presented and discussed in four categories: (1) alkali and alkaline earth elements, (2) non-metals, (3) metals, and (4) lanthanide and actinide elements.

### Sediment Samples

#### Total Digestion of Samples

Of the 36 elements analyzed following total digestion of a composite sample, 35 elements were detected in all 28 sediment samples, resulting in the detection of elements in 98 percent of the 1,008 samples ([table 10](#); at back of report). The concentrations of alkali and alkaline earth elements varied considerably among sites ([table 11](#); at back of report), but the variation within sites was usually small. Relative percent differences between the concentrations of sediments in the composite and concentrations of sediments in the sections and concentrations of sediments left over from spent porewater samples generally were less than 10 percent, although greater differences were found in at least one sample for all elements except rubidium ([table 12](#); at back of report). Except for silver, concentrations greater than the reporting limit in all 28 samples were measured for all metals analyzed ([tables 10 and 13](#); at back of report). The variations of the concentrations of metals from samples within sites were greater than those of the alkali and alkaline earth elements ([table 14](#); at back of report). The concentrations of four lanthanide and actinide elements seemed to vary less than other elements both between sites ([table 15](#); at back of report) and within sites ([table 16](#); at back of report).

#### Sequential Selective Extraction

A dried aliquot from the composite sample from each site was sequentially and selectively extracted to estimate associations with sediment mineral phases. The percentage of concentrations of alkali and alkaline earth elements that were greater than the reporting limit were 86, 93, 98, and 99

percent for the first, second, and third extraction fractions, and the residual sediment, respectively ([table 10](#)). Concentrations of all alkali and alkaline earth elements analyzed in the four extraction fractions were greater than the reporting limit, except for cesium, lithium, potassium, and sodium. Cesium was detected in only 3 of 8 extracts from the first sequential selective extraction fraction; lithium was detected in 5 of 8 extracts from the first fraction; potassium was detected in 7 of 8 extracts from the residual fraction; and sodium was detected in 5 extracts from the first fraction, 2 of the 8 extracts from the second fraction, and 6 of 8 extracts from the third fraction ([tables 10 and 17](#); at back of report). Selenium was detected in 6 of the 8 extracts of the two non-metals analyzed in the third fraction. In contrast, arsenic was detected in all extracts from the second fraction and in all residual sediments. The percentage of concentrations of non-metals that were greater than the reporting limit were 44, 56, 56, and 56 percent for the first, second, and third extraction fractions, and the residual sediment, respectively ([table 10](#)). Aluminum, cadmium, cobalt, copper, iron, lead, manganese, vanadium, and zinc were the metals detected in the extracts and residual sediment from all sites ([table 18](#); at back of report). In contrast, silver was not detected in the extracts from the first three extract fractions and was detected only in the residual sediment from three sites. Bismuth was not detected in any extract from fractions 1 and 3, but was detected in 5 of 8 extracts from fractions 2 and in the residual sediment from all 8 sites. The percentage of concentrations of metals that were greater than the reporting limit were 65, 73, 69, and 84 percent for the first, second, and third extraction fractions and the residual sediment, respectively ([table 10](#)). Uranium was the only actinide element analyzed and was detected in all fraction extracts and residual sediment samples.

### Water Samples

Analysis of 121 samples of reservoir water, porewater, reservoir water overlying incubation cores, and supernatants from the higher energy tumbling experiments resulted in 6,776 elemental analyses ([table 10](#)). Overall, the concentrations of only 37 percent of the analyses of water samples were greater than the reporting limit. Seventy-seven percent of the analyses of alkali and alkaline earth determinations were greater than the reporting limit. Barium, calcium, magnesium, potassium, sodium, rubidium, and strontium were detected in all 121 samples, whereas beryllium was detected in only one porewater sample. The overall percentage of detected non-metals was 51 percent, and the percentage of detections ranged from 0 for selenium to 100 percent for silica. The overall percentage of metals detected in water samples was

33 percent. Aluminum and copper were the most frequently detected metals in water samples, with detections in 107 of the 121 samples. In contrast, bismuth, chromium, niobium, silver, and zirconium were not detected in any water sample. Only 14 percent of the analyses of lanthanide and actinide elements were greater than the reporting limit. Cerium and uranium were the most frequently detected lanthanide and actinide elements, and five of the lanthanide and actinide elements (holmium, lutetium, terbium, thorium, and thulium) were not detected in any water samples. Only 23 percent of the analyses of reservoir water, which had little contact with the sediments, were detected. The percentage of porewater concentrations that were greater than the reporting limit (47 percent) was only slightly less than that of the higher energy tumbling experiment (48 percent). The percentage of analyses of reservoir water overlying the incubation cores with concentrations greater than the reporting limit (29 percent) was intermediate between the reservoir water and the leachate from the higher energy tumbling experiments.

## Reservoir Water

The source of the samples of site water and the water column properties are described in [table 19](#) (at back of report). Of the 10 samples of reservoir water analyzed, beryllium and cesium were not detected in any samples and lithium was detected in only one sample ([tables 10 and 20](#), at back of report). Of the five non-metals analyzed, only selenium was not detected in any reservoir water sample. Concentrations of 9 of the 25 metals analyzed (aluminum, antimony, cadmium, cobalt, copper, manganese, lead, nickel, and zinc) were greater than the reporting limit ([table 21](#), at back of report). Concentrations of lead and zinc in reservoir water from a sealed box core were higher than those collected from the surface of the water column or those from a draining box core. It is not known if these elevated concentrations for reservoir water are due to proximity to the sediments or contamination from the box corer. Only 2 of the lanthanide and actinide elements (erbium and uranium) were detected in reservoir water ([table 22](#), at back of report). Twenty-three percent of all elements analyzed in reservoir water were detected. Within the group of elements, 71 percent of the alkali and alkaline earth element analyses, 38 percent of the non-metal analyses, 15 percent of the metal analyses, and 1 percent of the lanthanide and actinide element analyses were detected, respectively ([table 10](#)).

## Porewaters

Thirty-two samples from eight sites were analyzed either as single porewater samples from an individual core or as composite porewater samples from multiple cores ([table 19](#)). Seven of the 10 alkali and alkaline earth elements and one (silica) of the five non-metals were detected in all 32 porewater samples ([tables 10 and 23](#), at back of report).

Selenium was the only non-metal element not detected in any samples of porewater. Concentrations of only one analysis of beryllium and seven analyses of lithium were greater than the reporting limit. Bismuth, chromium, niobium, silver, thallium, and zirconium were not detected in any porewater samples ([table 24](#); at back of report). Only aluminum and lead were detected in all 32 porewater samples. Cerium and neodymium were the most frequently detected lanthanide elements in porewater samples ([table 25](#); at back of report). Within the group of elements analyzed in 32 porewater samples, 81 percent of the alkali and alkaline earth element analyses, 54 percent of the non-metal analyses, 42 percent of the metal analyses, and 29 percent of lanthanide and actinide element analyses were greater than the reporting limit, respectively ([table 10](#)).

## Water Overlying Incubation Cores

Eight cores between 3 cm long (LR-7) and 12.3 cm long (LR-4A) were incubated with between 142 and 382 mL of reservoir water overlying the sediment ([table 26](#), at back of report). Concentrations of elements from 55 incubation samples collected from reservoir water overlying the eight cores between September 22 and November 3, 2004, are listed in [tables 27, 28, and 29](#) (at back of report). Concentrations of seven of the 10 alkali and alkaline earth elements were detected in all 55 samples ([tables 10 and 27](#)). No incubation sample had concentrations of beryllium greater than the reporting limit, and only one sample had concentrations of lithium greater than the reporting limit. For the non-metals, silica and sulfate were detected in all incubation samples, but selenium was not detected in any incubation samples ([table 27](#)). Bismuth, chromium, niobium, silver, tantalum, titanium, thallium, vanadium, and zirconium were not detected in water from any incubation sample ([table 28](#)). In contrast, copper was detected in all 55 incubation samples ([table 28](#)). Only five (cerium, europium, gadolinium, uranium and ytterbium) of the 16 lanthanide and actinide elements were detected in one or more incubation samples. Uranium was detected in 24 of the 55 incubation samples ([table 29](#)). Within the group of elements analyzed in the 55 incubation samples, 74 percent of the alkali and alkaline earth element analyses, 49 percent of the non-metal analyses, 24 percent of the metal analyses, and 4 percent of rare earth element analyses were detected, respectively.

## Supernatants from Higher Energy Tumbling Experiment

The top sediment from eight incubation cores, the bottom sediment from two cores, and two samples of river sediment with slag were tumbled for 43 days. Weights of dry sediment, of porewater contained in the original sample, and of site water added to the bottles during the tumbling experiment are given in [table 30](#) (at back of report). Seven of the 10 alkali and

alkaline earth elements were detected in all 24 samples from the tumbling experiment (tables 10 and 31, at back of report). Beryllium was not detected in any samples from the tumbling experiment, and concentrations of lithium in only 10 samples were greater than the reporting limit. For the non-metals, concentrations for all analyses of silica, 21 analyses of arsenic, and 13 of the analyses of sulfate were greater than the reporting limit in 24 tumbling experiment samples. Bismuth, chromium, niobium, silver, tantalum, and zirconium elements were not detected in any of the tumbling samples (table 32, at back of report). Aluminum, manganese and zinc were detected in all 24 samples from the tumbling experiment. Six of the 16 lanthanide and actinide elements were not detected in any tumbling experiment samples (table 33, at back of report). In contrast, cerium was detected in 22 of 24 samples from the tumbling experiment. Within the group of elements analyzed in 24 samples from the tumbling experiments, 81 percent of the alkali and alkaline earth element analyses, 56 percent of the non-metal analyses, 48 percent of the metal analyses, and 22 percent of the lanthanide and actinide element analyses were detected, respectively.

## Summary

The total digestion of 28 field samples from eight sites resulted in 1,008 analyses for the concentration of 10 alkali and alkaline earth elements, 2 non-metals, 20 metals, and 4 lanthanide and actinide elements. Concentrations of laboratory control samples and of blind standard reference materials generally were within acceptable ranges. Total elemental concentrations after a strong-acid digestion of the 9 composite and 19 individual sediment samples were detected for 95 percent of the analyses. Alkali and alkaline earth elements were detected in 100 percent of the sediment samples. The frequency of detection generally increased with the severity of the chemical treatment used during the sequential selective extractions procedure. For the weakest treatment that produced the first fraction, 76 percent of the elements were detected, and 93 percent of the analyses were greater than the reporting limits following four-acid dissolution of the residual sediment remaining after the first three extraction fractions.

Analysis of 121 samples of reservoir water, porewater, water overlying incubation cores, and leachates from the tumbling experiments for 56 elements resulted in 6,776 elemental analyses. Overall, the concentrations of 37 percent of the analyses of water samples were greater than the reporting limit. The overall percentage of detected non-metal elements was 51 percent, and ranged from 0 percent for selenium to 100 percent for silica in water samples. The overall percentage of detections for metals was 33 percent. Aluminum and copper were the most frequently detected

metal in water samples, with detections in 107 of 121 samples. In contrast, bismuth, chromium, silver and zirconium were not detected in any water samples. Only 14 percent of the analyses of lanthanide and actinide elements were greater than the reporting limit. Cerium and uranium were the most frequently detected lanthanide and actinide elements. In contrast, five lanthanide and actinide elements (holmium, lutetium, terbium, thorium, and thulium) were not detected in any water samples.

The percentage of detected elements of each type of water sample generally reflects the extent of contact with sediment phases. Only 23 percent of the analyses of reservoir water, which had little contact with the sediments, were detected. The percentage of porewater concentrations that were greater than the reporting limit (47 percent) was only slightly less than that of the higher energy tumbling experiment (48 percent). The percentage of analyses of water overlying the incubation cores with concentrations greater than the reporting limit (29 percent) was intermediate between the reservoir water and the leachate from the higher energy tumbling experiments.

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**Table 3.** Quality-control data for analysis of sediments.

[All concentrations are in micrograms per gram. **RPD**, relative percent difference of replicate measurements equal to  $100 \times (\text{difference of measurement 1 and measurement 2 divided by the average of measurement 1 and measurement 2})$ . **Abbreviations:** I, reported values or replicate measurements are identical within significant figures of the reporting unit; NC, not certified; –, not applicable or available. **Symbols:** <, less than]

Analytical sequence No.	Sample No.	Parameter	Aluminum	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cadmium	Calcium
Laboratory samples										
9	LR-1	Analytical result	66,100	0.83	9.0	799	2.4	0.29	0.25	13,700
41		Analytical result	68,000	.91	9.1	809	2.4	.26	.24	14,300
42		Analytical result	63,500	.81	8.9	746	2.1	.27	.23	13,600
		RPD (seq. 41 and 42)	6.8	11.6	2.2	8.1	13.3	3.8	4.3	5.0
		RPD ( seq. 9 and avg) (seq. 41 and 42)	.5	3.6	4.1	2.8	6.9	9.3	6.5	1.8
SSE	BCR-701	Analytical result	86,200	2.3	44	573	3.3	2.00	11.8	19,200
	BCR-701D	Analytical result	86,700	2.3	43	577	3.2	2.00	12.0	19,400
		RPD	.6	I	2.3	.7	3.1	I	1.7	1.0
4	MAG-1	Analytical result	85,100	.99	10	491	3.2	.35	.21	9,780
		Assumed true value <sup>1</sup>	86,660	.96	9.2	479	3.2	.34	.20	9,790
		Percent difference	-1.8	3.1	8.7	2.5	I	2.9	5	-.1
6	NIST 2704	NIST 2704 analytical result	62,800	3.9	23	422	2.2	.62	3.6	26,200
		Assumed true value <sup>1</sup>	61,090	3.79	23.4	414	NC	NC	3.45	26,000
		Percent difference	2.8	2.9	-1.7	1.9	–	–	4	.8
5	SCO-1	Analytical result	71,600	2.5	13	588	2.0	.37	.15	18,800
		Assumed true value <sup>1</sup>	72,370	2.5	12.4	570	1.84	.37	.14	18,700
		Percent difference	-1.1	<0.4	4.8	3.2	8.7	I	7	.5
30	MAG-1	Analytical result	86,100	.99	9.8	495	3.1	.34	.22	9,930
		Assumed true value <sup>1</sup>	86,660	.96	9.2	479	3.20	.34	.20	9,790
		Percent difference	-.6	3	6.5	3.3	-3.1	I	8	1.4
		RPD ( seq. 4 and 30)	1.9	I	2.0	1.2	5.1	3.3	1.2	1.3
Average percent difference			-0.2	2.3	4.6	2.7	1.9	1.0	6.1	0.7
Blind standards submitted from the field										
	PACS-2	Analytical result	63,900	12.1	27	794	1.1	.32	2.1	19,700
		Analytical result	63,300	12.5	28	765	1.1	.32	2.2	19,800
		Certified value	66,200	11.3	26.2	NC	1.0	NC	2.11	19,600
		Percent difference	-3.9	8.8	5.0	–	10.0	–	1.9	.8
		RPD	.9	3.3	3.6	3.7	I	I	4.7	.5
	IAEA-405	Analytical result	86,400	1.4	25	387	3.8	1.21	.8	29,700
		Certified value	77,900	1.81	23.6	NC	NC	NC	.73	NC
		Percent difference	10.9	-22.7	5.9	–	–	–	9.6	–
	LR-7	RPD of field duplicates	.9	6.5	6.5	1.4	11.8	47.1	15.4	.1
Reporting limit			8	0.02	0.1	0.5	0.001	0.005	0.003	20

**Table 3.** Quality-control data for analysis of sediments.—Continued

[All concentrations are in micrograms per gram. **RPD**, relative percent difference of replicate measurements equal to  $100 \times (\text{difference of measurement 1 and measurement 2 divided by the average of measurement 1 and measurement 2})$ . **Abbreviations:** I, reported values or replicate measurements are identical within significant figures of the reporting unit; NC, not certified; —, not applicable or available. **Symbols:** <, less than]

Analytical sequence No.	Sample No.	Parameter	Cerium	Cesium	Chromium	Cobalt	Copper	Gallium	Iron	Lanthanum
Laboratory samples										
9	LR-1	Analytical result	82.0	4.7	45.8	6.8	12.1	16	28,000	46.3
41		Analytical result	72.8	4.7	46.6	7.0	12.5	16	30,000	38.6
42		Analytical result	75.8	4.3	44.7	6.7	11.9	15	28,000	42.8
		RPD (seq. 41 and 42)	4.0	8.9	4.2	4.4	4.9	6.5	6.9	10.3
		RPD (seq. 9 and avg) (seq. 41 and 42)	10.3	4.5	.3	.7	.8	3.3	3.5	13.4
SSE	BCR-701	Analytical result	88.7	5.8	393	17.1	271	18.5	40,100	43.7
	BCR-701D	Analytical result	88.7	5.8	391	17.3	272	18.8	41,100	43.4
		RPD	I	I	.5	1.2	.4	1.6	2.5	.7
4	MAG-1	Analytical result	87.9	8.2	109	22.2	30.2	22	49,000	43.3
		Assumed true value <sup>1</sup>	88.0	8.60	97	20.4	30.0	20.4	47,600	43.0
		Percent difference	-.1	-4.7	12.4	8.8	.7	7.8	2.9	.7
6	NIST 2704	Analytical result	60.4	5.6	148	14.0	101	16	43,000	31.1
		Assumed true value <sup>1</sup>	72.0	6.00	135	14.0	98.6	15.0	41,100	29.0
		Percent difference	-16.1	-6.7	9.6	I	2.4	6.7	4.6	7.2
5	SCO-1	Analytical result	54.9	7.4	74.1	11.1	29.1	16	36,000	30.6
		Assumed true value <sup>1</sup>	62.0	7.80	68.0	10.5	28.7	15.0	35,900	29.5
		Percent difference	-11.5	-5.1	9.0	5.7	1.4	6.7	0.3	3.7
30	MAG-1	Analytical result	82.0	8.2	109	22.1	29.6	22	49,000	43.4
		Assumed true value <sup>1</sup>	88.0	8.6	97	20.4	30.0	20.4	47,600	43.0
		Percent difference	-6.8	-4.7	12.4	8.3	-1.3	7.8	2.9	.9
		RPD ( seq. 4 and 30)	11.6	I	I	.9	1.7	I	I	.4
Average percent difference			-8.6	-5.3	10.8	5.7	0.8	7.3	2.7	3.1
Blind standards submitted from the field										
	PACS-2	Analytical result	30.7	2.0	90.8	11.5	298	13	41,000	16.3
		Analytical result	32.1	2.0	93.4	11.7	309	13	42,000	16.7
		Certified value	NC	NC	90.7	11.5	310	NC	40,900	NC
		Percent difference	—	—	1.5	.9	-2.1	—	1.5	—
		RPD	4.5	I	2.8	1.7	3.6	I	2.4	2.4
	IAEA-405	Analytical result	64.4	11.7	93.3	14.1	50.4	22	40,000	33.4
		Certified value	NC	12.5	84	13.7	47.7	NC	37,400	40.4
		Percent difference	—	-6.4	11.1	2.9	5.7	—	7.0	-17.3
	LR-7	RPD of field duplicates	5.2	I	4.1	.2	2.3	I	I	5.1
Reporting limit			0.5	0.003	0.2	0.1	0.5	0.006	50	0.3

**Table 3.** Quality-control data for analysis of sediments.—Continued

[All concentrations are in micrograms per gram. **RPD**, relative percent difference of replicate measurements equal to  $100 \times (\text{difference of measurement 1 and measurement 2 divided by the average of measurement 1 and measurement 2})$ . **Abbreviations:** I, reported values or replicate measurements are identical within significant figures of the reporting unit; NC, not certified; —, not applicable or available. **Symbols:** <, less than]

Analytical sequence No.	Sample No.	Parameter	Lead	Lithium	Magne-sium	Man-ganese	Molyb-denum	Nickel	Phos-phorus	Potas-sium
Laboratory samples										
9	LR-1	Analytical result	15.9	27.0	9,530	455	0.31	14.1	570	25,500
41		Analytical result	15.8	26.3	10,100	477	.42	15.0	560	27,600
42		Analytical result	15.0	24.8	9,260	448	.33	14.0	550	25,500
		RPD (seq. 41 and 42)	5.2	5.9	8.7	6.3	24.0	6.9	1.8	7.9
		RPD (seq. 9 and avg) (seq. 41 and 42)	3.3	5.8	1.6	1.6	18.4	2.8	2.7	4.0
SSE	BCR-701	Analytical result	152	42.9	16,200	774	3.1	113	3,210	23,700
	BCR-701D	Analytical result	153	42.3	16,100	790	3.4	114	3,260	24,500
		RPD	.7	1.4	.6	2.0	9.2	.9	1.6	3.3
4	MAG-1	Analytical result	25.0	75.1	18,600	751	1.0	50.5	740	30,400
		Assumed true value <sup>1</sup>	24.0	79.0	18,090	760	1.60	53.0	711	29,500
		Percent difference	4.2	-4.9	2.8	-1.2	-37.5	-4.7	4.1	3.1
6	NIST 2704	Analytical result	170	47.8	12,600	591	3.9	44.2	1,000	20,300
		Assumed true value <sup>1</sup>	161	47.5	12,000	555	NC	44.1	1,000	20,000
		Percent difference	5.6	.6	5.0	6.5	—	.2	I	1.5
5	SCO-1	Analytical result	29.0	43.7	16,800	384	1.1	25.7	950	22,300
		Assumed true value <sup>1</sup>	31.0	45.0	16,400	410	1.37	27.0	899	23,000
		Percent difference	-6.5	-2.9	2.4	-6.3	-19.7	-4.8	5.7	-3.0
30	MAG-1	Analytical result	25.0	73.3	18,800	743	1.1	49.9	740	30,500
		Assumed true value <sup>1</sup>	24.0	79.0	18,090	760	1.60	53.0	711	29,500
		Percent difference	4.2	-7.2	3.9	-2.2	-31.3	-5.8	4.1	3.4
		RPD ( seq. 4 and 30)	I	4.4	1.8	1.9	8.4	2.0	I	.6
Average percent difference			1.9	-3.6	3.5	-.8	-29.5	-3.8	3.5	1.2
Blind standards submitted from the field										
	PACS-2	Analytical result	179	30.4	14,600	428	5.2	38.6	1,000	12,200
		Analytical result	176	30.6	14,600	439	5.2	39.6	1,000	12,700
		Certified value	183	32.2	14,700	440	5.43	39.5	960	12,400
		Percent difference	-3.0	-5.3	-.7	-1.5	-4.2	-1.0	4.2	.4
		RPD	1.7	.7	I	2.5	I	2.6	I	4.0
	IAEA-405	Analytical result	72.3	83.9	13,900	522	0.73	33	1200	26,200
		Certified value	74.8	72	12,300	495	NC	32.5	NC	24,900
		Percent difference	-3.3	16.5	13.0	5.5	—	1.5	—	5.2
	LR-7	RPD of field duplicates	5.0	1.6	1.7	1.6	.6	4.0	2.2	.7
Reporting limit			0.2	0.2	0.3	0.2	0.1	1	8	0.6

**Table 3.** Quality-control data for analysis of sediments.—Continued

[All concentrations are in micrograms per gram. **RPD**, relative percent difference of replicate measurements equal to  $100 \times$  (difference of measurement 1 and measurement 2 divided by the average of measurement 1 and measurement 2. **Abbreviations:** I, reported values or replicate measurements are identical within significant figures of the reporting unit; NC, not certified; –, not applicable or available. **Symbols:** <, less than]

Analytical sequence No.	Sample No.	Parameter	Rubidium	Scandium	Silver	Sodium	Strontium
Laboratory samples							
9	LR-1	Analytical result	115	9.6	<3	14,600	317
41		Analytical result	119	10.3	<3	15,000	317
42		Analytical result	110	9.3	<3	14,000	302
		RPD (seq. 41 and 42)	7.9	10.2	–	6.9	4.8
		RPD (seq. 9 and avg) (seq. 41 and 42)	0.4	2.1	–	.7	2.5
SSE	BCR-701	Analytical result	114	13.8	8.7	15,100	180
	BCR-701D	Analytical result	113	13.9	8.8	14,900	181
		RPD	.9	.7	1.1	1.3	.6
4	MAG-1	Analytical result	146	18.6	<3	28,500	142
		Assumed true value <sup>1</sup>	149	17.2	0.08	28,400	146
		Percent difference	-2.0	8.1	–	.4	-2.7
6	NIST 2704	Analytical result	101	12.7	<3	5,690	136
		Assumed true value <sup>1</sup>	100	12.0	NC	5,470	130
		Percent difference	1.0	5.8	–	4.0	4.6
5	SCO-1	Analytical result	109	12.3	<3	6,930	169
		Assumed true value <sup>1</sup>	112	10.8	.134	6,670	174
		Percent difference	-2.7	13.9	–	3.9	-2.9
30	MAG-1	Analytical result	145	18.6	< 3	28,400	142
		Assumed true value <sup>1</sup>	149	17.2	.08	28,400	146
		Percent difference	-2.7	8.1	–	I	-2.7
		RPD (seq. 4 and 30)	1.2	I	–	.9	I
Average percent difference			-1.6	9.0	–	2.1	-0.9
Blind standards submitted from the field							
	PACS-2	Analytical result	39.9	14.4	<3	33,200	273
		Analytical result	40.5	14.8	<3	33,400	272
		Certified value	NC	NC	1.22	NC	276
		Percent difference	–	–	–	–	-1.3
		RPD	1.5	2.7	–	.6	.4
	IAEA-405	Analytical result	156	15.1	<3	16,600	146
		Certified value	NC	NC	–	NC	118
		Percent difference	–	–	–	–	23.7
	LR-7	RPD of field duplicates	.7	I	5.1	3.9	.6
Reporting limit			0.01	0.3	3	6	0.05

**Table 3.** Quality-control data for analysis of sediments.—Continued

[All concentrations are in micrograms per gram. **RPD**, relative percent difference of replicate measurements equal to  $100 \times$  (difference of measurement 1 and measurement 2 divided by the average of measurement 1 and measurement 2. **Abbreviations:** I, reported values or replicate measurements are identical within significant figures of the reporting unit; NC, not certified; —, not applicable or available. **Symbols:** <, less than]

Analytical sequence No.	Sample No.	Parameter	Thallium	Thorium	Titanium	Uranium	Vanadium	Yttrium	Zinc
Laboratory samples									
9	LR-1	Analytical result	0.72	14.7	2,500	3.8	70.4	18.7	75.2
41		Analytical result	.74	11.0	2,800	2.3	74.0	18.6	77.2
42		Analytical result	.69	14.0	2,500	3.5	70.3	17.5	74.0
		RPD (seq. 41 and 42)	7.0	24.0	11.3	41.4	5.1	6.1	4.2
		RPD (seq. 9 and avg) (seq. 41 and 42)	.7	16.6	5.8	28.1	2.5	3.7	.5
SSE	BCR-701	Analytical result	.82	14.6	4,380	5.51	93	26.1	466
	BCR-701D	Analytical result	.84	14.6	4,430	5.46	95	26.2	481
		RPD	2.4	.7	1.1	.9	-2.0	.4	-3.2
4	MAG-1	Analytical result	.76	12.6	4,300	2.8	146	24.4	135
		Assumed true value <sup>1</sup>	.59	11.9	4,500	2.70	140	28.0	130
		Percent difference	28.8	5.9	-4.4	3.7	4.3	-12.9	3.8
6	NIST 2704	Analytical result	1.2	9.4	3,100	3.2	97.8	25.2	445
		Assumed true value <sup>1</sup>	1.06	9.2	4,580	3.13	95.0	NC	438
		Percent difference	13.2	2.2	-32.3	2.2	2.9	—	1.6
5	SCO-1	Analytical result	.70	9.7	3,200	3.0	134	21.8	104
		Assumed true value <sup>1</sup>	.72	9.7	3,760	3.00	131	26.0	103
		Percent difference	-2.8	I	-14.9	I	2.3	-16.2	1.0
30	MAG-1	Analytical result	.77	12.2	4,300	2.8	147	24.7	134
		Assumed true value <sup>1</sup>	.59	11.9	4,500	2.70	140	28.0	130
		Percent difference	30.5	2.5	-4.4	3.7	5.0	-11.8	3.1
		RPD (seq. 4 and 30)	1.6	5.3	I	I	1.1	1.6	.7
Average percent difference			17.4	2.6	-14.0	2.4	3.6	-13.6	2.4
Blind standards submitted from the field									
	PACS-2	Analytical result	0.60	3.9	4,700	2.3	136	17	371
		Analytical result	.61	4	4,800	2.3	139	17.3	373
		Certified value	.60	NC	4,430	3	133	NC	364
		Percent difference	.83	—	7.2	-23.3	3.4	—	2.2
		RPD	1.7	2.5	2.1	I	2.2	1.7	.5
	IAEA-405	Analytical result	1	13.5	3,700	3.2	102	21.1	287
		Certified value	NC	14.3	NC	3.01	95	NC	279
		Percent difference	—	-5.6	—	6.3	7.4	—	2.9
	LR-7	RPD of field duplicates	I	17.7	I	2.1	.4	1.4	1.1
Reporting limit			0.003	0.03	40	0.02	0.4	0.3	5

<sup>1</sup>Potts and others, 1992.

**Table 4.** Interlaboratory comparison for analysis of arsenic, cadmium, copper, lead, and zinc in the composite samples.

[Used average of duplicate four-acid digestion results. **Abbreviations:** RPD, relative percent difference; –, negative indicates result from U.S. Geological Survey Columbia Environmental Research Center laboratory is lower than result from U.S. Geological Survey Mineral Laboratory]

Site identifier	Composite samples (in RPD)				
	Arsenic	Cadmium	Copper	Lead	Zinc
LR-1	-4.7	30.5	-18.0	-50.3	7.4
LR-2	-1.4	12.5	-.1	10.0	18.7
LR-3	2.3	5.9	-.9	-4.5	13.4
LR-4	-11.9	-13.3	-6.7	-67.5	-5.7
LR-5	7.2	17.5	13.2	2.3	21.0
LR-6	-19.7	3.0	4.2	-.5	11.3
LR-7	4.1	107.5	5.9	28.0	34.6
SA-8	-12.1	23.3	-9.4	-29.3	3.4
Mean	-4.5	23.4	-1.5	-14.0	13.0



**Table 5.** Quality-control data for analysis of sequential selective extraction of sediments.—Continued

[All concentrations are in micrograms per gram **RPD**, relative percent difference. **Abbreviations:** I, reported values or replicate measurements are identical within significant figures of the reporting unit; NC, not certified; NR, not reported. **Symbols:** —, not applicable or available; <, less than]

Parameter	Alumi- num	Anti- mony	Arsenic	Barium	Beryl- lium	Bismuth	Cad- mium	Calcium
Laboratory replicates of sample LR-5 (Composite)								
<b>Fraction 1</b>								
LR-5	58	0.21	0.5	48.4	0.07	<0.04	1.89	13,100
LR-5R	57	.20	.5	47.7	.08	<.04	1.75	12,900
RPD	1.7	4.9	I	1.5	13.3	25	7.7	1.5
<b>Fraction 2</b>								
LR-5	1,300	.25	2.0	60.4	.20	.16	.73	5,770
LR-5R	1,260	.21	2.0	58.5	.10	.18	.67	5,630
RPD	3.1	17.4	I	3.2	66.7	11.8	8.6	2.5
<b>Fraction 3</b>								
LR-5	568	.06	<.2	27.8	.05	<.04	.64	272
LR-5R	595	<.06	<.2	26.7	.03	<.04	.52	267
RPD	4.6	—	—	4.0	50.0	25	20.7	1.9
<b>Residual fraction</b>								
LR-5	23,900	2.26	3.2	816	1.2	.16	.25	6,690
LR-5R	17,900	1.95	2.0	951	1.1	.43	.34	9,640
RPD	28.9	14.7	46.2	15.3	8.7	91.5	30.5	36.1
Reporting limit	0.4	0.06	0.2	0.04	0.01	0.04	0.004	40

**Table 5.** Quality-control data for analysis of sequential selective extraction of sediments.—Continued

[All concentrations are in micrograms per gram **RPD**, relative percent difference. **Abbreviations:** I, reported values or replicate measurements are identical within significant figures of the reporting unit; NC, not certified; NR, not reported. **Symbols:** –, not applicable or available; <, less than]

Parameter	Cesium	Chromium	Cobalt	Copper	Gallium	Germa- nium	Iron	Lead
Concentrations of process and wash blanks BCR-701								
<b>Average concentrations in wash blanks</b>								
Fraction 1	<0.004	0.2	<0.004	<0.1	<0.01	<0.01	<10	<0.01
Fraction 2	<.004	1.3	<.004	<.1	<.01	<.01	<10	<.01
Fraction 3	<.004	<.2	<.004	<.1	<.01	<.01	<10	<.01
<b>Concentration in process blanks</b>								
Fraction 1	<.004	.3	<.004	<.01	<.01	<.01	<10	.01
Fraction 2	<.004	<.2	<.004	<.01	<.01	<.01	<10	.04
Fraction 3	<.004	2.3	<.004	<.01	<.01	<.01	<10	<.01
Fraction 4	<.004	<.2	<.004	.02	.02	<.01	<10	.06
Laboratory replication and recovery of standard reference material BCR-701								
<b>BCR-701 Fraction 1</b>								
Analytical result	0.01	2.3	1.93	46.0	0.01	0.01	72	2.8
Analytical result	.01	2.4	1.98	47.1	.01	<.01	74	2.8
Average concentration	.01	2.4	1.96	46.6	.01	<.01	73	2.8
RPD	I	4.3	2.6	2.4	I	–	2.7	I
Certified value	NC	2.3	NC	49.3	NC	NC	NC	3.2
Average percentage difference from certified value	–	4.0	–	-5.6	–	–	–	-11.9
<b>BCR-701 Fraction 2</b>								
Analytical result	.19	41.7	2.99	113.0	.64	.03	7,020	113.0
Analytical result	.19	42.7	3.04	114.0	.66	.03	7,230	117.0
Average concentration	.19	42.2	3.02	113.5	.65	.03	7,125	115.0
RPD	I	2.4	1.7	0.9	3.1	I	2.9	3.5
Certified value	NC	45.7	NC	124.0	NC	NC	NC	126.0
Average percentage difference from certified value	–	-7.7	–	-8.5	–	–	–	-8.7
<b>BCR-701 Fraction 3</b>								
Analytical result	.12	135.0	1.36	53.3	.10	.02	656	4.7
Analytical result	.10	136.0	1.34	51.3	.10	<.01	621	4.6
Average concentration	.11	135.5	1.35	52.3	.10	<.02	639	4.7
RPD	18.2	.7	1.5	3.8	I	–	5.5	2.2
Certified value	NC	143.0	NC	55.2	NC	NC	NC	9.3
Average percentage difference from certified value	–	-5.2	–	-5.3	–	–	–	-49.5

**Table 5.** Quality-control data for analysis of sequential selective extraction of sediments.—Continued

[All concentrations are in micrograms per gram **RPD**, relative percent difference. **Abbreviations:** I, reported values or replicate measurements are identical within significant figures of the reporting unit; NC, not certified; NR, not reported. **Symbols:** —, not applicable or available; <, less than]

Parameter	Cesium	Chromium	Cobalt	Copper	Gallium	Germanium	Iron	Lead
Laboratory replicates of sample LR-5 (Composite)								
<b>Fraction 1</b>								
LR-5	<0.004	0.6	0.80	15.2	<0.01	0.06	910	30.4
LR-5R	<.004	.6	.81	15.1	<.01	.05	904	29.4
RPD	—	17	1.2	.7	—	18.2	.7	3.3
<b>Fraction 2</b>								
LR-5	.10	2.9	1.98	23.0	.40	.05	5,960	145.0
LR-5R	.10	2.9	1.95	22.8	.39	.04	5,900	141.0
RPD	I	I	1.5	.9	2.5	22.2	1.0	2.8
<b>Fraction 3</b>								
LR-5	.09	4.5	.64	15.3	.03	<.01	893	11.2
LR-5R	.09	5.2	.66	14.7	.03	<.01	925	12.2
RPD	I	14.4	3.1	4.0	I	—	3.5	8.5
<b>Residual fraction</b>								
LR-5	1.91	22.7	3.42	11.0	10.9	1.80	15,700	15.5
LR-5R	1.90	50.8	4.29	10.8	12.4	1.40	17,700	15.0
RPD	.5	76.5	22.6	1.8	12.9	25.0	12.0	3.3
Reporting limit	0.004	0.2	0.004	0.1	0.01	0.01	10	0.01

**Table 5.** Quality-control data for analysis of sequential selective extraction of sediments.—Continued

[All concentrations are in micrograms per gram **RPD**, relative percent difference. **Abbreviations:** I, reported values or replicate measurements are identical within significant figures of the reporting unit; NC, not certified; NR, not reported. **Symbols:** —, not applicable or available; <, less than]

Parameter	Lithium	Magne- sium	Manga- nese	Molyb- denum	Nickel	Potas- sium	Rubidium
Concentrations of process and wash blanks BCR-701							
<b>Average concentrations in wash blanks</b>							
Fraction 1	<0.2	<2	<0.04	<0.4	<0.08	<6	<0.002
Fraction 2	<.2	<2	<.04	<.4	<.08	<6	<.002
Fraction 3	<.2	<2	<.04	<.4	<.08	<6	<.002
<b>Concentration in process blanks</b>							
Fraction 1	<.2	2.4	<.04	<.4	<.08	<6	<.002
Fraction 2	<.2	<2	<.04	<.4	<.08	<6	<.002
Fraction 3	.2	<2	<.04	<.4	<.08	<6	<.002
Fraction 4	<.2	5.5	<.04	<.4	<.08	9.4	<.002
Laboratory replication and recovery of standard reference material BCR-701							
<b>BCR-701 Fraction 1</b>							
Analytical result	0.2	743	177	<0.4	14.0	99	0.28
Analytical result	.3	763	186	<.4	14.4	102	.29
Average concentration	.3	753	182	—	14.2	101	.29
RPD	40.0	2.7	5.0	—	2.8	3.0	3.5
Certified value	NC	NC	NC	NC	15.4	NC	NC
Average percentage difference from certified value	—	—	—	—	-7.8	—	—
<b>BCR-701 Fraction 2</b>							
Analytical result	.8	513	132	<.4	24.8	85	.86
Analytical result	.9	518	136	<.4	25.2	85	.88
Average concentration	.9	516	134	—	25.0	85	.87
RPD	11.8	1.0	3.0	—	1.6	0.9	2.3
Certified value	NC	NC	NC	NC	26.6	NC	NC
Average percentage difference from certified value	—	—	—	—	-6.0	—	—
<b>BCR-701 Fraction 3</b>							
Analytical result	2.1	486	22.3	.88	13.8	104	1.30
Analytical result	1.8	468	21.3	.81	13.6	100	1.27
Average concentration	2.0	477	21.8	.85	13.7	102	1.29
RPD	15.4	3.8	4.6	8.3	1.5	3.9	2.3
Certified value	NC	NC	NC	NC	15.3	NC	NC
Average percentage difference from certified value	—	—	—	—	-10.5	—	—

**Table 5.** Quality-control data for analysis of sequential selective extraction of sediments.—Continued

[All concentrations are in micrograms per gram **RPD**, relative percent difference. **Abbreviations:** I, reported values or replicate measurements are identical within significant figures of the reporting unit; NC, not certified; NR, not reported. **Symbols:** –, not applicable or available; <, less than]

Parameter	Lithium	Magne- sium	Man- ganese	Molyb- denum	Nickel	Potas- sium	Rubi- dium
Laboratory replicates of sample LR-5 (Composite)							
<b>Fraction 1</b>							
LR-5	0.2	6,850	104	<0.4	1.2	36	0.17
LR-5R	<.2	6,710	104	<.4	1.1	33	.16
RPD	–	2.1	I	–	8.7	8.8	6.1
<b>Fraction 2</b>							
LR-5	1.0	2,470	63	<.4	3.1	24	.44
LR-5R	.9	2,390	62	<.4	3.0	22	.44
RPD	10.5	3.3	2.4	–	3.3	7.4	I
<b>Fraction 3</b>							
LR-5	2.0	328	16.1	<.4	2.3	51	.53
LR-5R	1.8	331	16.2	<.4	2.2	47	.51
RPD	10.5	0.9	.6	–	4.4	7.6	3.8
<b>Residual fraction</b>							
LR-5	13.1	4,810	182	.83	NR	16,500	54.7
LR-5R	11.9	4,460	201	.77	14.5	NR	45.5
RPD	9.6	7.6	9.9	7.5	–	–	18.4
Reporting limit	0.2	2	0.04	0.4	0.08	6	0.002

**Table 5.** Quality control data for analysis of sequential selective extraction of sediments.—Continued

[All concentrations are in micrograms per gram **RPD**, relative percent difference. **Abbreviations:** I, reported values or replicate measurements are identical within significant figures of the reporting unit; NC, not certified; NR, not reported. **Symbols:** —, not applicable or available; <, less than]

Parameter	Selenium	Silver	Sodium	Strontium	Thallium	Uranium	Vana- dium	Zinc
Concentrations of process and wash blanks BCR-701								
<b>Average concentrations in wash blanks</b>								
Fraction 1	<0.2	<0.6	<20	<0.1	<0.02	<0.02	<0.1	<0.1
Fraction 2	<.2	<.6	<20	<.1	<.02	<.02	<.1	<.1
Fraction 3	<.2	<.6	<20	<.1	<.02	<.02	<.1	<.1
<b>Concentration in process blanks</b>								
Fraction 1	<.2	<.6	<20	<.1	<.02	<.02	<.1	<.1
Fraction 2	<.2	<.6	<20	<.1	<.02	<.02	<.1	<.1
Fraction 3	<.2	<.6	<20	<.1	<.02	<.02	.6	<.1
Fraction 4	<.2	<.6	<20	.31	<.02	<.02	<.1	0.2
Laboratory replication and recovery of standard reference material BCR-701								
<b>BCR-701 Fraction 1</b>								
Analytical result	<0.2	<0.6	47.5	44.5	<0.02	0.06	0.5	188.0
Analytical result	<.2	<.6	48.7	45.2	<.02	.06	.5	195.0
Average concentration	—	—	48.1	44.9	—	.06	.5	191.5
RPD	—	—	2.5	1.6	—	I	I	3.7
Certified value	NC	NC	NC	NC	NC	NC	NC	205.0
Average percentage difference from certified value	—	—	—	—	—	—	—	-6.6
<b>BCR-701 Fraction 2</b>								
Analytical result	<.2	3.72	< 20	12.2	.07	.65	10.6	104.0
Analytical result	<.2	3.81	< 20	12.4	.07	.67	11.1	104.0
Average concentration	—	3.77	—	12.3	.07	.66	10.9	104.0
RPD	—	2.4	—	1.6	I	3.0	4.6	I
Certified value	NC	NC	NC	NC	NC	NC	NC	114.0
Average percentage difference from certified value	—	—	—	—	—	—	—	-8.8
<b>BCR-701 Fraction 3</b>								
Analytical result	1	1.03	31.1	1.8	.02	1.54	2.0	43.3
Analytical result	1	0.99	26.4	1.7	.02	1.56	2.3	40.0
Average concentration	1	1.01	28.8	1.7	.02	1.55	2.2	41.7
RPD	I	4.0	16.3	5.7	I	1.3	14.0	7.9
Certified value	NC	NC	NC	NC	NC	NC	NC	45.7
Average percentage difference from certified value	—	—	—	—	—	—	—	-8.8

**Table 5.** Quality control data for analysis of sequential selective extraction of sediments.—Continued

[All concentrations are in micrograms per gram **RPD**, relative percent difference. **Abbreviations:** I, reported values or replicate measurements are identical within significant figures of the reporting unit; NC, not certified; NR, not reported. **Symbols:** –, not applicable or available; <, less than]

	Selenium	Silver	Sodium	Strontium	Thallium	Uranium	Vana- dium	Zinc
Laboratory replicates of sample LR-5 (Composite)								
<b>Fraction 1</b>								
LR-5	<0.2	<0.6	<20	12.1	0.02	0.20	0.3	187.0
LR-5R	<.2	<.6	<20	11.9	<.02	.18	.3	183.0
RPD	–	–	–	1.7	–	10.5	33	2.2
<b>Fraction 2</b>								
LR-5	<.2	<.6	<20	9.9	.10	.49	7.0	331.0
LR-5R	<.2	<.6	<20	9.7	.09	.47	6.8	323.0
RPD	–	–	–	1.8	10.5	4.2	2.9	2.4
<b>Fraction 3</b>								
LR-5	<.2	<.6	26.8	1.7	.04	.77	.9	118.0
LR-5R	<.2	<.6	28.5	1.8	.04	.74	1.1	97.2
RPD	–	–	6.1	2.3	I	4.0	20.0	19.3
<b>Residual fraction</b>								
LR-5	<.2	<.6	12,900	289	.40	1.03	45.5	102.0
LR-5R	<.2	<.6	15,600	323	.40	1.13	43.9	116
RPD	–	–	18.9	11.1	I	9.3	3.6	12.8
Reporting limit	0.2	0.6	20	0.1	0.02	0.02	0.1	0.1

**Table 6.** Analyses of field filtering blanks and results from submission of blind water reference standards.

[Concentrations in micrograms per liter unless otherwise indicated. **Abbreviations:** I, reported values or replicate measurements are identical within significant figures of the reporting unit; ILOD, instrumental limit of detection; NC, not certified; USGS, U.S. Geological Survey; NRCC, National Research Center of Canada; NIST, National Institute of Science and Technology; RPD, relative percent difference; 3\*Stdev., 3 times standard deviation; n, number of samples. **Symbols:** –, not applicable or available; <, less than]

	Alumi- num	Anti- mony	Arsenic	Barium	Beryl- lium	Bismuth	Cad- mium	Calcium (mg/L)	Cerium	Cesium	Chro- mium	Cobalt
Filtering blanks (n = 3)												
Average	10.0	<ILOD	<ILOD	<ILOD	<ILOD	<ILOD	<ILOD	<ILOD	<ILOD	<ILOD	<ILOD	<ILOD
3* Stdev.	4.3	–	–	–	–	–	–	–	–	–	–	–
NRCC - SLRS-3 (n = 2)												
Analytical result	43.3	<0.3	1	12.8	<0.05	<0.2	<0.1	5.84	0.26	<0.02	<5	<0.01
Analytical result	38.3	<.3	1	12.1	<.05	<.2	<.1	5.22	.27	<.02	<5	<.01
Certified value	31	.12	.72	13.4	.005	NC	.013	6.0	NC	NC	.3	.027
Recovery (percent)	131	–	140	92.9	–	–	–	92	–	–	–	–
RPD (percent)	12.3	–	I	5.6	–	–	–	11.2	3.8	–	–	–
USGS SRS T-171 (n = 1)												
Analytical result	28.4	2.6	3.4	13.4	0.8	<0.2	5.04	6.68	0.11	0.02	<5	4.73
Certified value	19.4	2.73	3.5	13.6	1.18	NC	4.92	6.75	NC	NC	3.1	4.71
Recovery (percent)	146	95	97	99	70	–	102	99.0	–	–	–	100
USGS SRS T-179 (n = 2)												
Analytical result	68.4	3.42	2	35.1	3.3	<0.2	4.34	18.5	0.48	<0.02	<5	1.07
Analytical result	62.8	3.40	2	33.9	3.3	<.2	4.38	18.1	.44	<.02	<5	1.11
Certified value	51.7	3.66	1.9	36.0	3.74	NC	4.42	18.9	NC	NC	NC	1.10
Recovery (percent)	127	93.2	105	95.8	88	–	98.6	96.8	–	–	–	99.1
RPD (percent)	8.5	.6	I	3.5	I	–	.9	2.2	8.7	–	–	3.7
NIST 1640 (n = 1)												
Analytical result	60.4	13.2	25.5	136	34.2	<0.2	22.3	7.14	0.36	0.12	36.0	20.8
Certified value	52.0	13.8	26.7	148	34.9	NC	22.8	7.05	NC	NC	38.6	20.3
Recovery (percent)	116	95.7	95.6	91.9	97.9	–	97.8	101	–	–	93	103
NIST 1643e (n = 2)												
Analytical result	176	59.3	58.3	538	13.7	14.4	6.87	33.8	<0.05	<0.02	21.9	28.6
Analytical result	199	57.1	56.4	527	13.2	14.1	6.68	33.6	.05	<.02	21.5	27.7
Certified value	142	58.3	60.5	544	14.0	14.1	6.57	32.3	NC	NC	20.4	27.1
Recovery (percent)	132	99.8	94.9	97.9	96.2	101	103	104	–	–	106	104
RPD (percent)	12.3	3.8	3.3	2.1	3.7	3.7	3.7	.6	–	–	1.8	3.2
Reporting limit	10	0.3	1	1	0.05	0.2	0.1	1	0.05	0.02	5	0.1

**Table 6.** Analyses of field filtering blanks and results from submission of blind water reference standards.—Continued

[Concentrations in micrograms per liter unless otherwise indicated. **Abbreviations:** I, reported values or replicate measurements are identical within significant figures of the reporting unit; ILOD, instrumental limit of detection; NC, not certified; USGS, U.S. Geological Survey; NRCC, National Research Center of Canada; NIST, National Institute of Science and Technology; RPD, relative percent difference; 3\*Stdev., 3 times standard deviation; n, number of samples. **Symbols:** –, not applicable or available; <, less than]

	Copper	Dyspro- sium	Erbium	Euro- pium	Gallium	Gado- linium	Germa- nium	Holmium	Iron	Lantha- num	Lead
Filtering blanks (n = 3)											
Average 3* Stdev.	<ILOD –	<ILOD –	<ILOD –	<ILOD –	<ILOD –	<ILOD –	<ILOD –	<ILOD –	<ILOD –	<ILOD –	<ILOD –
NRCC - SLRS-3 (n = 2)											
Analytical result	0.97	<0.04	<0.025	<0.025	<0.05	<0.025	<0.25	<0.025	<250	0.24	<0.25
Analytical result	.56	.05	<.025	<.025	<.05	.03	<.25	<.025	<250	.23	<.25
Certified value	1.35	NC	NC	NC	NC	NC	NC	NC	100	NC	.086
Recovery (percent)	57	–	–	–	–	–	–	–	–	–	–
RPD (percent)	54	–	–	–	–	–	–	–	–	4.3	–
USGS SRS T-171 (n = 1)											
Analytical result	<0.5	<0.04	<0.025	<0.025	<0.05	<0.025	<0.25	<0.025	<250	<0.1	1.1
Certified value	1.0	NC	NC	NC	NC	NC	NC	NC	53.4	NC	1.09
Recovery (percent)	–	–	–	–	–	–	–	–	–	–	101
USGS SRS T-179 (n = 2)											
Analytical result	3.0	0.04	0.04	<0.025	<0.05	0.064	<0.25	<0.025	<250	0.38	2.0
Analytical result	3.6	<.04	.05	<.025	<.05	.086	<.25	<.025	<250	.37	1.9
Certified value	3.86	NC	NC	NC	NC	NC	NC	NC	125	NC	1.86
Recovery (percent)	86	–	–	–	–	–	–	–	–	–	105
RPD (percent)	18	–	–	–	–	25.2	–	–	–	2.7	5.1
NIST 1640 (n = 1)											
Analytical result	88.7	<0.04	<0.025	<0.025	<0.05	0.03	<0.25	<0.04	<250	0.3	27.7
Certified value	85.2	NC	NC	NC	NC	NC	NC	NC	34.3	NC	27.9
Recovery (percent)	104	–	–	–	–	–	–	–	–	–	99.3
NIST 1643e (n = 2)											
Analytical result	22.8	<0.04	<0.025	0.075	<0.05	<0.005	<0.25	<0.025	<250	0.02	20.0
Analytical result	23.2	<.04	<.025	.11	<.05	<.025	<.25	<.025	<250	.04	20.1
Certified value	22.8	NC	NC	NC	NC	NC	NC	NC	98	NC	19.6
Recovery (percent)	101	–	–	–	–	–	–	–	–	–	102
RPD (percent)	1.7	–	–	37.8	–	–	–	–	–	66.7	.5
Reporting limit	0.5	0.04	0.025	0.025	0.05	0.025	0.25	.025	250	0.1	0.25

**Table 6.** Analyses of field filtering blanks and results from submission of blind water reference standards.—Continued

[Concentrations in micrograms per liter unless otherwise indicated. **Abbreviations:** I, reported values or replicate measurements are identical within significant figures of the reporting unit; ILOD, instrumental limit of detection; NC, not certified; USGS, U.S. Geological Survey; NRCC, National Research Center of Canada; NIST, National Institute of Science and Technology; RPD, relative percent difference; 3\*Stdev., 3 times standard deviation; n, number of samples. **Symbols:** –, not applicable or available; <, less than]

	Lithium	Lutetium	Magne- sium (mg/L)	Man- ganese	Molyb- denum	Neody- mium	Nickel	Nio- bium	Phos- phorus (mg/L)	Potas- sium (mg/L)	Praseody- mium
Filtering blanks (n = 3)											
Average 3* Stdev.	<ILOD –	<ILOD –	<ILOD –	1.5 5.1	<ILOD –	<ILOD –	<ILOD –	<ILOD –	<ILOD –	0.13 .17	<ILOD –
NRCC - SLRS-3 (n = 2)											
Analytical result	<4.5	<0.5	1.75	8.0	<2	0.25	1.0	<1	<0.05	0.92	0.06
Analytical result	<4.5	<.5	1.55	12.1	<2	.20	.6	<1	<.05	.69	.06
Certified value	NC	NC	1.6	3.9	.19	NC	.83	NC	.7	.7	NC
Recovery (percent)	–	–	42.3	260	–	–	96	–	–	120	–
RPD (percent)	–	–	12.1	41	–	22	50	–	–	29	I
USGS SRS T-171 (n = 1)											
Analytical result	5.2	<0.5	2.94	29.7	<2	0.08	5.5	<1	0.2	3.12	<0.05
Certified value	6.3	NC	2.78	12.4	1.97	NC	5.67	NC	NC	2.80	NC
Recovery (percent)	83	–	106	240	–	–	97	–	–	111	–
USGS SRS T-179 (n = 2)											
Analytical result	9.1	<0.5	4.89	44.6	2	0.43	0.9	<1	<0.05	1.69	0.09
Analytical result	7.7	<.5	4.77	45.4	2	.43	3.0	<1	<.05	1.61	.11
Certified value	6.50	NC	4.59	44.2	NC	NC	1.41	NC	NC	1.40	NC
Recovery (percent)	130	–	105	102	–	–	140	–	–	118	–
RPD (percent)	17	–	2.5	1.8	–	–	110	–	–	4.8	20
NIST 1640 (n = 1)											
Analytical result	54.2	<0.5	6.2	126	44.6	0.39	28.2	<1	<0.05	1.2	0.11
Certified value	50.7	NC	5.82	122	46.8	NC	27.4	NC	NC	.99	NC
Recovery (percent)	107	–	110	104	95.4	–	103	–	–	120	–
NIST 1643e (n = 2)											
Analytical result	22.0	<0.5	9.06	42.2	118	<0.05	64.2	<1	0.08	2.53	<0.05
Analytical result	20.2	<.5	8.82	40.5	118	<.05	63.8	<1	.08	2.50	<.05
Certified value	17.4	NC	8.04	39.0	121	NC	62.4	NC	NC	2.03	NC
Recovery (percent)	121	–	111	106	97.5	–	103	–	–	124	–
RPD (percent)	8.5	–	2.7	4.1	I	–	.6	–	–	1.2	–
Reporting limit	4.5	0.5	0.05	5	2	0.05	0.4	1	0.05	0.15	0.05

**Table 6.** Analyses of field filtering blanks and results from submission of blind water reference standards.—Continued

[Concentrations in micrograms per liter unless otherwise indicated. **Abbreviations:** I, reported values or replicate measurements are identical within significant figures of the reporting unit; ILOD, instrumental limit of detection; NC, not certified; USGS, U.S. Geological Survey; NRCC, National Research Center of Canada; NIST, National Institute of Science and Technology; RPD, relative percent difference; 3\*Stdev., 3 times standard deviation; n, number of samples. **Symbols:** –, not applicable or available; <, less than]

	Rubi- dium	Sama- rium	Scan- dium	Sele- nium	Silica (mg/L)	Silver	Sodium (mg/L)	Stron- tium	Sulfate (mg/L)	Tantalum	Terbium
Filtering blanks (n = 3)											
Average	<ILOD	<ILOD	<ILOD	<ILOD	<ILOD	<ILOD	<ILOD	<ILOD	<ILOD	<ILOD	<ILOD
3* Stdev.	–	–	–	–	–	–	–	–	–	–	–
NRCC - SLRS-3 (n = 2)											
Analytical result	1.58	<0.09	<3	<5	3.2	<15	2.64	30.7	12	<0.1	<0.025
Analytical result	1.34	<.09	<3	<5	2.8	<15	2.36	28.3	<10	<.1	<.025
Certified value	NC	NC	NC	NC	NC	NC	2.3	28.1	NC	NC	NC
Recovery (percent)	–	–	–	–	–	–	110	105	–	–	–
RPD (percent)	16.4	–	–	–	13.3	–	11.2	8.1	–	–	–
USGS SRS T-171 (n = 1)											
Analytical result	0.98	<0.09	<3	<5	3.0	<15	9.33	81.7	<10	<0.1	<0.025
Certified value	NC	NC	NC	1.4	3.5	NC	8.60	84.0	NC	NC	NC
Recovery (percent)	–	–	–	–	86	–	109	97.3	–	–	–
USGS SRS T-179 (n = 2)											
Analytical result	0.34	<0.09	<3	<5	13.6	<15	28	109	12	<0.1	<0.025
Analytical result	.38	<.09	<3	<5	13.6	<15	27	107	<10	<.1	<.025
Certified value	NC	NC	NC	NC	14.9	NC	26.2	113	NC	NC	NC
Recovery (percent)	–	–	–	–	91.3	–	105	95.6	–	–	–
RPD (percent)	11.1	–	–	–	I	–	3.6	1.9	–	–	–
NIST 1640 (n = 1)											
Analytical result	1.89	<0.09	<3	22.4	9.5	<15	31.4	119	<10	<0.1	<0.025
Certified value	2.00	NC	NC	21.96	10.1	7.6	29.4	124.2	NC	NC	NC
Recovery (percent)	94.5	–	–	102	94	–	107	95.8	–	–	–
NIST 1643e (n = 2)											
Analytical result	14.0	<0.09	<3	13.1	<1	<15	23.9	322	16	<0.1	<0.025
Analytical result	13.6	<.09	<3	11.6	<1	<15	23.1	315	<10	<.1	<.025
Certified value	14.1	NC	NC	12.0	NC	1.0	20.7	323	NC	NC	NC
Recovery (percent)	97.6	–	–	103	–	–	114	98.6	–	–	–
RPD (percent)	2.9	–	–	12.1	–	–	3.4	2.2	–	–	–
Reporting limit	0.05	0.09	3	5	1	15	0.5	2.5	10	0.1	0.025

**Table 6.** Analyses of field filtering blanks and results from submission of blind water reference standards.—Continued

[Concentrations in micrograms per liter unless otherwise indicated. **Abbreviations:** I, reported values or replicate measurements are identical within significant figures of the reporting unit; ILOD, instrumental limit of detection; NC, not certified; USGS, U.S. Geological Survey; NRCC, National Research Center of Canada; NIST, National Institute of Science and Technology; RPD, relative percent difference; 3\*Stdev., 3 times standard deviation; n, number of samples. **Symbols:** –, not applicable or available; <, less than]

	Thal- lium	Tho- rium	Thu- lium	Tita- nium	Tung- sten	Ura- nium	Vana- dium	Ytter- bium	Yttrium	Zinc	Zirco- nium
Filtering blanks (n = 3)											
Average	<ILOD	<ILOD	<ILOD	<ILOD	<ILOD	<ILOD	<ILOD	<ILOD	<ILOD	<ILOD	<ILOD
3* Stdev.	–	–	–	–	–	–	–	–	–	–	–
NRCC - SLRS-3 (n = 2)											
Analytical result	<0.2	<1	<0.045	<2.5	<0.5	<0.5	<2.5	<0.025	0.11	<2.5	<1
Analytical result	<.2	<1	<0.045	<2.5	<.5	<.5	<2.5	<.025	.1	<2.5	<1
Certified value	NC	NC	NC	NC	NC	.045	.3	NC	NC	1.04	NC
Recovery (percent)	–	–	–	–	–	–	–	–	–	–	–
RPD (percent)	–	–	–	–	–	–	–	–	–	–	–
USGS SRS T-171 (n = 1)											
Analytical result	8.1	<1	<0.045	<2.5	<0.5	1.22	<2.5	0.05	0.1	5.2	<1
Certified value	8.35	NC	NC	NC	NC	1.23	2.39	NC	NC	6.21	NC
Recovery (percent)	97	–	–	–	–	99.2	–	–	–	84	–
USGS SRS T-179 (n = 2)											
Analytical result	1.3	<1	<0.045	<2.5	<0.5	1.56	2.5	0.03	0.27	7.3	<1
Analytical result	1.3	<1	<.045	<2.5	<.5	1.53	<2.5	.05	.27	7.5	<1
Certified value	1.33	NC	NC	NC	NC	1.55	NC	NC	NC	8.50	NC
Recovery (percent)	98	–	–	–	–	99.7	–	–	–	87	–
RPD (percent)	I	–	–	–	–	1.9	–	50	–	2.7	–
NIST 1640 (n = 1)											
Analytical result	<0.2	<1	<0.045	<2.5	<0.5	0.76	12	<0.025	0.18	52.9	<1
Certified value	NC	NC	NC	NC	NC	NC	13.0	NC	NC	53.2	NC
Recovery (percent)	–	–	–	–	–	–	92	–	–	99.4	–
NIST 1643e (n = 2)											
Analytical result	7.5	<1	<0.045	<2.5	<0.5	<0.5	39.9	<0.025	<0.05	81	<1
Analytical result	7.6	<1	<0.045	<2.5	<.5	<.5	38.5	<.025	<.05	80.3	<1
Certified value	7.45	NC	NC	NC	NC	NC	37.9	NC	NC	78.5	NC
Recovery (percent)	101	–	–	–	–	–	104	–	–	103	–
RPD (percent)	1.3	–	–	–	–	–	3.6	–	–	.9	–
Reporting limit	0.2	1	0.045	2.5	0.5	0.5	2.5	0.025	0.05	2.5	1

**Table 7.** Quality-assurance assessment of water samples.

[**Assessment:** SRM, standard reference material; RPD, relative percent difference; RL, reporting limit; ILOD, instrumental limit of detection; SLRS-3, freshwater standard reference material issued by National Research Council of Canada. **Abbreviations:** µg/L, micrograms per liter. **Symbols:** <, less than; ×, times]

Element	Assessment
Aluminum	Recovery of SRM high (116 percent to 146 percent) at concentration between 28 and 200 µg/L.
Antimony	Good recovery and RPD at 10 × original ILOD.
Arsenic	Good recovery of SRM (103 percent) and RPD <10 percent at 2 × original ILOD.
Barium	RL increased by 5 for dilution, no data lost.
Beryllium	Informational data, no SRM data to evaluate.
Bismuth	Informational data, no SRM data to evaluate.
Cadmium	RL increased by 5 for dilution, RPD of 13 percent at 1.5 × RL.
Calcium	RL increased by 5 for dilution, no data lost.
Cerium	Informational data, no SRM to evaluate. RL increased by 5 for dilution.
Cesium	Informational data, no SRM to evaluate.
Chromium	RL increased by 5 for dilution.
Cobalt	75 percent recovery and high RPD near original ILOD, RL increased by 5 for dilution.
Copper	One of two analysis of SLRS-3 was low.
Dysprosium	Informational data, no SRM to evaluate. RL increased by 5 for dilution.
Erbium	Informational data, no SRM to evaluate. RL increased by 5 for dilution.
Europium	Informational data, no SRM to evaluate. RL increased by 5 for dilution.
Gadolinium	Informational data, no SRM to evaluate. RL increased by 5 for dilution.
Gallium	Informational data, no SRM to evaluate. Good RPD near original ILOD.
Germanium	Informational data, no SRM to evaluate. RL increased by 5 for dilution.
Holmium	Informational data, no SRM to evaluate. RL increased by 5 for dilution.
Iron	Informational data, no SRM to evaluate. RL increased by 5 for dilution.
Lanthanum	Informational data, no SRM to evaluate. RL increased by 10. Five percent RPD at 2 × RL.
Lead	ILOD increased by 5 for dilution. 101 percent recovery at 4 times RL.
Lithium	ILOD increased by 5 for dilution, no data lost.
Lutetium	Informational data, no SRM to evaluate. RL increased by 5 for dilution.
Magnesium	RL increased by 5 for dilution, no data lost.
Manganese	Reporting limit of 5 µg/L determined by field laboratory filtering blanks.
Molybdenum	92 percent recovery near ILOD. RPD <10 percent at 2 × RL.
Neodymium	Informational data, no SRM to evaluate. RL increased by 5 for dilution.
Nickel	50 percent RPD for SLRS-3.
Niobium	Informational data, no SRM to evaluate. RL increased by 5 for dilution.
Phosphorus	Informational data, no SRM to evaluate. RL increased by 5 for dilution.
Potassium	RL increased by 5 for dilution.
Praseodymium	Informational data, no SRM to evaluate. RL increased by 5 for dilution. Low RPD near RL.
Rubidium	RL increased by 5 for dilution.
Samarium	RL of 0.09 µg/L determined by field laboratory filtering blanks.
Scandium	Informational data, no SRM to evaluate. RL increased by 5 for dilution.
Selenium	RL increased by 5 for dilution.
Silica	RL increased by 5 for dilution. RPD of 13 percent at 3 × RL.
Silver	RL increased by 5 for dilution.
Sodium	RPD <10 percent at 3 to 4 × RL.
Strontium	RL increased by 5 for dilution.
Sulfate	Informational data, no SRM to evaluate. RL increased by 5 for dilution. RPD high at 2 to 3 × RL.
Tantalum	Informational data, no SRM to evaluate. RL increased by 5 for dilution.
Terbium	Informational data, no SRM to evaluate. RL increased by 5 for dilution.
Thallium	Informational data, no SRM to evaluate. RL increased by 5 for dilution.
Thorium	Informational data, no SRM to evaluate. RL increased by 5 for dilution.
Thulium	Informational data, no SRM to evaluate. RL increased by 5 for dilution.
Titanium	Informational data, no SRM to evaluate. RL increased by 5 for dilution.
Tungsten	Informational data, no SRM to evaluate. RPD of 11 percent at 1.5 × RL.
Uranium	RL increased by 5 for dilution. 99 percent recovery with 3 × RL for two SRMs.
Vanadium	RL increased by 5 for dilution.
Ytterbium	Informational data, no SRM to evaluate. RL increased by 5 for dilution.
Yttrium	Informational data, no SRM to evaluate. RL increased by 5 for dilution.
Zinc	RL increased by 5 for dilution. Recovery 83 percent to 87 percent at 2 to 3 × RL. RL for incubations experiments increased to 3.3 µg/L based on the control experiment.
Zirconium	Informational data, no SRM to evaluate. RL increased by 5 for dilution.

**Table 8.** Water samples identified as outliers.

[All concentrations in micrograms per liter]

Site identifier	Sample identifier	Element	Concentration
LR-1	LR-1OV	Nickel	4.3
LR-6	LR-6INC8	Lead	15
LR-7	LR-7AINC4	Cobalt	5.9
Control	LR-9INC0A	Aluminum	66.6
Control	LR-9INC0A	Antimony	1.74

**Table 9.** Results of incubation control experiment.

[Concentrations in microgram per liter unless otherwise indicated. Probability represents the chance that results at 1 hour and 34 days are the same. **Abbreviations:** mg/L, milligram per liter; OTL, outlier (see [table 8](#)); Avg., average; Std. Dev., standard deviation. **Symbols:** <, less than; –, not applicable]

Sample identifier	Time		Aluminum	Antimony	Arsenic	Barium	Beryllium	Bismuth	Cadmium
LR-9INC0A	1 hour		OTL	OTL	<1	22.0	<0.05	<0.2	<.1
LR-9INC0B	1 hour		<10	0.3	<1	21.5	<.05	<.2	<.1
LR-9INC0C	1 hour		11.7	.3	<1	23.2	<.05	<.2	<.1
LR-9INC34A	34 days		12.1	.31	<1	27.3	<.05	<.2	<.1
LR-9INC34B	34 days		17.2	.39	1	38.1	<.05	<.2	<.1
LR-9INC34C	34 days		13.1	.3	<1	27.4	<.05	<.2	<.1
	1 hour	Avg.	–	0.3	–	22.2	–	–	–
		Std. Dev.	–	<.1	–	.9	–	–	–
	34 days	Avg.	14.1	0.3	–	30.9	–	–	–
		Std. Dev.	2.7	.05	–	6.2	–	–	–
		Probability	–	.36	–	.13	–	–	–

Sample identifier	Time		Calcium (mg/L)	Cerium	Cesium	Chromium	Cobalt	Copper	Dysprosium
LR-9INC0A	1 hour		15.3	<0.05	<0.02	<5	<0.1	<0.5	<0.04
LR-9INC0B	1 hour		16.0	<.05	<.02	<5	<.1	<.5	<.04
LR-9INC0C	1 hour		16.0	<.05	<.02	<5	<.1	<.5	<.04
LR-9INC34A	34 days		18.4	<.05	<.02	<5	<.1	<.5	<.04
LR-9INC34B	34 days		25.0	<.05	<.02	<5	<.1	.97	<.04
LR-9INC34C	34 days		19.4	<.05	<.02	<5	<.1	.5	<.04
	1 hour	Avg.	15.8	–	–	–	–	–	–
		Std. Dev.	0.4	–	–	–	–	–	–
	34 days	Avg.	20.9	–	–	–	–	–	–
		Std. Dev.	3.6	–	–	–	–	–	–
		Probability	.13	–	–	–	–	–	–

**Table 9.** Results of incubation control experiment.—Continued

[Concentrations in microgram per liter unless otherwise indicated. Probability represents the chance that results at 1 hour and 34 days are the same. **Abbreviations:** mg/L, milligram per liter; OTL, outlier (see [table 8](#)); Avg., average; Std. Dev., standard deviation. **Symbols:** <, less than; –, not applicable]

Sample identifier	Time	Parameter	Erbium	Europium	Gallium	Gadolinium	Germanium	Holmium	Iron
LR-9INC0A	1 hour		<0.005	<0.025	<0.05	<0.025	<0.25	<0.025	<250
LR-9INC0B	1 hour		<.005	<.025	<.05	<.025	<.25	<.025	<250
LR-9INC0C	1 hour		<.005	<.025	<.05	<.025	<.25	<.025	<250
LR-9INC34A	34 days		<.005	<.025	<.05	<.025	<.25	<.025	<250
LR-9INC34B	34 days		<.005	<.025	<.05	<.025	<.25	<.025	<250
LR-9INC34C	34 days		<.005	<.025	<.05	<.025	<.25	<.025	<250
	1 hour	Avg.	–	–	–	–	–	–	–
		Std. Dev.	–	–	–	–	–	–	–
	34 days	Avg.	–	–	–	–	–	–	–
		Std. Dev.	–	–	–	–	–	–	–
		Probability	–	–	–	–	–	–	–

Sample identifier	Time	Parameter	Lanthanum	Lead	Lithium	Lutetium	Magnesium (mg/L)	Manganese	Molybdenum
LR-9INC0A	1 hour		<0.1	<0.25	<4.5	<0.5	4.96	<5	<2
LR-9INC0B	1 hour		<.1	<.25	<4.5	<.5	4.97	<5	<2
LR-9INC0C	1 hour		<.1	<.25	<4.5	<.5	5.09	<5	<2
LR-9INC34A	34 days		<.1	<.25	<4.5	<.5	5.29	<5	<2
LR-9INC34B	34 days		<.1	<.25	<4.5	<.5	7.30	<5	<2
LR-9INC34C	34 days		<.1	<.25	<4.5	<.5	5.47	<5	<2
	1 hour	Avg.	–	–	–	–	5.0	–	–
		Std. Dev.	–	–	–	–	0.1	–	–
	34 days	Avg.	–	–	–	–	6.0	–	–
		Std. Dev.	–	–	–	–	1.1	–	–
		Probability	–	–	–	–	.26	–	–

Sample identifier	Time	Parameter	Neodymium	Nickel	Niobium	Phosphorus	Potassium (mg/L)	Praseodymium	Rubidium
LR-9INC0A	1 hour		<0.05	<0.4	<1	<0.05	0.97	<0.05	0.99
LR-9INC0B	1 hour		<.05	<.4	<1	<.05	.94	<.05	.99
LR-9INC0C	1 hour		<.05	<.4	<1	<.05	.95	<.05	1.00
LR-9INC34A	34 days		<.05	<.4	<1	<.05	.94	<.05	1.01
LR-9INC34B	34 days		<.05	<.4	<1	<.05	1.33	<.05	1.45
LR-9INC34C	34 days		<.05	<.4	<1	<.05	1.05	<.01	1.11
	1 hour	Avg.	–	–	–	–	1.0	–	1.0
		Std. Dev.	–	–	–	–	.0	–	.0
	34 days	Avg.	–	–	–	–	1.1	–	1.2
		Std. Dev.	–	–	–	–	.2	–	.2
		Probability	–	–	–	–	.32	–	.28

**Table 9.** Results of incubation control experiment.—Continued

[Concentrations in microgram per liter unless otherwise indicated. Probability represents the chance that results at 1 hour and 34 days are the same. **Abbreviations:** mg/L, milligram per liter; OTL, outlier (see [table 8](#)); Avg., average; Std. Dev., standard deviation. **Symbols:** <, less than; –, not applicable]

Sample identifier	Time	Parameter	Samarium	Scandium	Selenium	Silicon (mg/L)	Silver	Sodium (mg/L)	Strontium
LR-9INC0A	1 hour		<0.09	<3	<5	3.2	<15	2.14	79.0
LR-9INC0B	1 hour		<.09	<3	<5	2.8	<15	2.11	80.9
LR-9INC0C	1 hour		<.09	<3	<5	3.0	<15	2.10	82.3
LR-9INC34A	34 days		<.09	<3	<5	3.5	<15	2.26	92.3
LR-9INC34B	34 days		<.09	<3	<5	4.4	<15	3.30	127
LR-9INC34C	34 days		<.09	<3	<5	3.7	<15	2.32	93.4
	1 hour	Avg.	–	–	–	3.0	–	2.1	80.7
		Std. Dev.	–	–	–	.2	–	.03	1.7
	34 days	Avg.	–	–	–	3.9	–	2.6	104.2
		Std. Dev.	–	–	–	0.5	–	0.6	19.7
		Probability	–	–	–	.07	–	.27	.17

Sample identifier	Time	Parameter	Sulfate (mg/L)	Tantalum	Terbium	Thalium	Thorium	Thulium	Titanium
LR-9INC0A	1 hour		24	<0.1	<0.01	<0.1	<1	<0.045	<2.5
LR-9INC0B	1 hour		12	<.1	<.01	<.1	<1	<.045	<2.5
LR-9INC0C	1 hour		22	<.1	<.01	<.1	<1	<.045	<2.5
LR-9INC34A	34 days		14	<.1	<.01	<.1	<1	<.045	<2.5
LR-9INC34B	34 days		19	<.1	<.01	<.1	<1	<.045	<2.5
LR-9INC34C	34 days		28	<.1	<.01	<.1	<1	<.045	<2.5
	1 hour	Avg.	19.3	–	–	–	–	–	–
		Std. Dev.	6.4	–	–	–	–	–	–
	34 days	Avg.	20.3	–	–	–	–	–	–
		Std. Dev.	7.1	–	–	–	–	–	–
		Probability	.87	–	–	–	–	–	–

Sample identifier	Time	Parameter	Tungsten	Uranium	Vanadium	Yttrium	Ytterbium	Zinc	Zirconium
LR-9INC0A	1 hour		<0.5	<0.5	<0.5	<0.05	<0.025	<2.5	<0.2
LR-9INC0B	1 hour		<.5	<.5	<.5	<.05	<.025	<2.5	<.2
LR-9INC0C	1 hour		<.5	<.5	<.5	<.05	<.025	<2.5	<.2
LR-9INC34A	34 days		<.5	<.5	<.5	<.05	<.025	2.8	<.2
LR-9INC34B	34 days		<.5	<.5	<.5	<.05	<.025	4.3	<.2
LR-9INC34C	34 days		<.5	<.5	0.6	<.05	<.025	2.8	<.2
	1 hour	Avg.	–	–	–	–	–	–	–
		Std. Dev.	–	–	–	–	–	–	–
	34 days	Avg.	–	–	–	–	–	3.3	–
		Std. Dev.	–	–	–	–	–	0.9	–
		Probability	–	–	–	–	–	–	–

**Table 10.** Number of detections in sediments, selective extractants, reservoir waters, porewaters, incubation core samples, and supernatants of the tumbling experiments.

[Abbreviations: Res., residual; No., number; AAE, alkali and alkaline earth elements; NM, non-metals; L&amp;A, lanthanide and actinide; –, not analyzed]

		Analysis of solids						Analysis of liquids				
		Solids	Selective fraction				Total	Reservoir water	Pore-water	Incubation	Tumbling	Total
			1	2	3	Res.						
Total No. of samples		28	8	8	8	8	60	10	32	55	24	121
Alkali and Alkaline Earth Elements												
Detections	Barium	28	8	8	8	8	60	10	32	55	24	121
	Beryllium	28	8	8	8	8	60	0	1	0	0	1
	Calcium	28	8	8	8	8	60	10	32	55	24	121
	Cesium	28	3	8	8	8	55	0	27	20	17	64
	Lithium	28	5	8	8	8	57	1	7	1	10	19
	Magnesium	28	8	8	8	8	60	10	32	55	24	121
	Potassium	28	8	8	8	7	59	10	32	55	24	121
	Rubidium	28	8	8	8	8	60	10	32	55	24	121
	Sodium	28	5	2	6	8	49	10	32	55	24	121
	Strontium	28	8	8	8	8	60	10	32	55	24	121
Detections	AAE	280	69	74	78	79	580	71	259	406	195	931
Possible detections	AAE	280	80	80	80	80	600	100	320	350	240	1,210
Percentage of detections	AAE	100	86	93	98	99	97	71	81	74	81	77
Non-metals												
Detections	Arsenic	28	6	8	3	8	53	1	28	8	21	58
	Phosphorus	28	–	–	–	–	28	1	22	16	9	48
	Selenium	–	1	1	6	1	9	0	0	0	0	0
	Silicon	–	–	–	–	–	–	10	32	55	24	121
	Sulfate	–	–	–	–	–	–	7	5	55	13	80
Detections	NM	56	7	9	9	9	90	19	87	134	67	307
Possible detections	NM	56	16	16	16	16	120	50	160	275	120	605
Percentage of detections	NM	100	44	56	56	56	75	38	54	49	56	51
Metals												
Detections	Aluminum	28	8	8	8	8	60	10	32	41	24	107
	Antimony	28	4	5	3	8	48	3	28	29	21	81
	Bismuth	28	0	5	0	8	41	0	0	0	0	0
	Cadmium	28	8	8	8	8	60	1	11	8	13	33
	Chromium	28	8	7	8	8	59	0	0	0	0	0
	Cobalt	28	8	8	8	8	60	3	29	15	21	68
	Copper	28	8	8	8	8	60	6	26	55	20	107
	Gallium	28	4	8	8	8	56	0	17	16	18	51
	Germanium	–	4	6	5	8	23	0	5	2	12	19
	Iron	28	8	8	8	8	60	0	8	4	12	24
	Lead	28	8	8	8	8	60	7	32	23	22	84
	Manganese	28	8	8	8	8	60	3	30	31	24	88
	Molybdenum	28	1	1	2	5	37	0	13	20	19	52
	Nickel	28	8	8	8	6	58	1	26	21	19	67
	Niobium	–	–	–	–	–	0	0	0	0	0	0
	Scandium	28	–	–	–	–	28	0	6	16	9	31

**Table 10.** Number of detections in sediments, selective extractants, reservoir waters, porewaters, incubation core samples, and supernatants of the tumbling experiments.—Continued

[Abbreviations: Res., residual; AAE, alkali and alkaline earth elements; NM, non-metals; L&amp;A, lanthanide and actinide; NA, not analyzed]

Element or group		Analysis of solids						Analysis of liquids				
		Solids	Selective fraction				Total	Reservoir water	Pore-water	Incubation	Tumb-ling	Total
			1	2	3	Res.						
Metals—Continued												
Detections	Silver	4	0	0	0	3	7	0	0	0	0	0
	Tantalum	—	—	—	—	—	0	0	1	0	0	1
	Thallium	28	3	5	4	8	48	0	0	0	1	1
	Titanium	28	—	—	—	—	28	0	10	0	5	15
	Tungsten	—	—	—	—	—	0	0	8	5	8	21
	Vanadium	28	8	8	8	8	60	0	3	0	1	4
	Yttrium	28	—	—	—	—	28	0	31	2	21	54
	Zinc	28	8	8	8	8	60	3	29	38	24	94
	Zirconium	—	—	—	—	—	0	0	0	0	0	0
Detections	Metals	536	104	117	110	134	973	37	339	325	285	1,001
Possible detections	Metals	560	160	160	160	160	1,200	250	800	1,375	600	3,025
Percentage of detections	Metals	91	65	73	69	84	81	15	42	24	48	33
Lanthanide and actinide elements												
Detections	Cerium	28	—	—	—	—	28	0	31	4	22	57
	Dyprosium	—	—	—	—	—	—	0	7	0	1	8
	Erbium	—	—	—	—	—	—	1	4	0	2	7
	Europium	—	—	—	—	—	—	0	3	1	8	12
	Gadolinium	—	—	—	—	—	—	0	17	1	9	27
	Holmium	—	—	—	—	—	—	0	0	0	0	0
	Lanthanum	28	—	—	—	—	28	0	21	0	10	31
	Lutetium	—	—	—	—	—	—	0	0	0	0	0
	Neodymium	—	—	—	—	—	—	0	24	0	15	39
	Praseodymium	—	—	—	—	—	—	0	9	0	1	10
	Samarium	—	—	—	—	—	—	0	2	0	0	2
	Terbium	—	—	—	—	—	—	0	0	0	0	0
	Thorium	28	—	—	—	—	28	0	0	0	0	0
	Thulium	—	—	—	—	—	—	0	0	0	0	0
	Uranium	28	8	8	8	8	60	1	11	24	12	48
	Ytterbium	—	—	—	—	—	—	0	17	4	6	27
Detections	L&A	112	8	8	8	8	144	2	146	34	86	268
Possible detections	L&A	112	8	8	8	8	144	160	512	880	384	1,936
Percentage of detections	L&A	100	100	100	100	100	100	1	29	4	22	14
All elements												
Detections	All	984	188	208	205	230	1,815	129	837	899	642	2,507
Possible detections	All	1,098	248	248	248	248	2,000	560	1,792	3,080	1,344	6,776
Percentage of detections	All	98	76	84	83	93	91	23	47	29	48	37

**Table 11.** Concentrations of alkali and alkaline earth elements and non-metals in composite samples and field replicates.[All concentrations are in microgram per gram; **Abbreviations:** cm, centimeter; PW, porewater]

Site identifier	Sample identifier	Sample type	Alkali and Alkaline Earth Elements										Non-Metals	
			Barium	Beryllium	Calcium	Cesium	Lithium	Magnesium	Potassium	Rubidium	Sodium	Strontium	Arsenic	Phosphorus
LR-1	LR-1	Composite	799	2.4	13,700	4.7	27.0	9,530	25,500	115	14,600	317	9	570
	PW-1B	0-2 cm spent PW	793	2.5	11,900	5.2	27.8	10,400	27,200	124	14,300	297	9	680
	PW-1C	0-2 cm spent PW	803	2.4	11,400	5.0	27.9	9,880	27,500	126	14,400	296	10	580
LR-2	LR-2	Composite	1,060	2.9	11,300	7.6	45.0	14,800	24,700	127	11,000	249	22	1,500
	LR-2A	0-1 cm	1,080	2.9	12,200	7.8	43.9	15,700	25,800	130	11,100	267	22	1,500
	LR-2B	7-10 cm	1,060	2.9	12,400	7.3	43.2	14,400	24,800	126	12,100	262	25	1,200
LR-3	LR-3	Composite	1,180	2.7	15,400	5.2	33.6	13,200	24,400	108	16,400	400	13	1,500
	LR-3A	0-1 cm	1,100	2.5	15,300	5.0	31.8	13,100	23,600	105	15,100	386	15	1,500
	LR-3B	5-6 cm	1,210	2.6	16,100	5.3	35.1	14,000	26,000	114	16,700	411	14	1,600
LR-4	LR-4	Composite	1,240	2.4	17,600	1.8	15.9	7,920	26,800	93	23,500	601	3	690
	PW-4A	0-2 cm spent PW	1,220	2.3	16,000	1.8	15.4	7,760	26,600	89	23,700	586	3	690
	PW-4F	0-2 cm spent PW	1,210	2.1	16,600	2.1	16.3	8,360	26,000	92	22,300	567	3	800
LR-4A	TM-4AINC	0-2 cm spent tumbled core	1,090	3.0	16,700	4.9	42.1	14,800	24,900	101	17,000	399	9	1,700
LR-5	LR-5	Composite	1,460	2.3	32,600	2.8	21.3	18,000	21,300	81	18,500	486	8	1,200
	PW-5A	0-2 cm spent PW	1,210	2.2	26,600	4.1	27.5	16,800	19,400	83	15,000	376	11	1,600
	PW-5B	0-2 cm spent PW	1,480	1.9	37,400	2.8	21.0	22,200	18,900	73	15,600	408	10	1,300
	PW-5D	0-2 cm spent PW	1,460	2.1	30,200	2.9	20.8	17,800	21,300	80	17,800	433	8	1,200
LR-5A	TM-5AINC	0-2 cm spent tumbled core	1,300	3.0	36,200	2.8	30.2	18,400	22,000	78	19,200	479	9	1,600
LR-6	LR-6	Composite	1,430	1.9	43,400	2.0	17.0	19,700	19,200	69	17,200	482	12	1,200
	LR-6A	0-1 cm	1,530	2.4	40,100	2.2	19.3	19,500	21,300	76	19,300	530	10	1,400
	LR-6B	3-4 cm	1,670	2.2	44,200	1.9	17.3	20,600	21,200	73	18,400	523	11	1,400
LR-7	LR-7	Composite	2,110	1.6	83,600	1.8	18.9	11,500	14,500	59	10,100	476	32	940
	LR-7R	Composite	2,140	1.8	83,500	1.8	19.2	11,700	14,600	58	10,500	479	30	920
	PW-7E	0-2 cm spent PW	1,980	1.5	84,400	2.0	18.5	13,100	14,600	59	9,960	438	30	1,000
	PW-7F	0-2 cm spent PW	1,800	1.5	85,500	2.2	19.5	14,600	15,500	64	10,600	425	30	1,000
SA-8	SA-8	Composite	1,030	2.4	18,800	5.1	32.6	12,900	25,000	104	17,300	492	10	1,100
	SA-8A	0-1 cm	956	2.4	16,100	6.2	36.7	14,000	24,800	112	14,500	401	9	1,300
	SA-8B	5-7 cm	983	2.5	18,200	5.5	34.7	13,600	24,500	107	16,300	479	7	1,200
	<sup>1</sup> RM 743	0-1 cm	3,100	1.4	95,400	0.8	18.2	9,570	6,870	22.8	5,080	444	46.8	687

<sup>1</sup>RM 743 is a sample of unsorted beach sand containing slag that was collected from river mile 743 of the Columbia River on September 13, 2002 and analyzed as part of a previous study (Cox and others, 2005).

**Table 12.** Vertical and horizontal variation of concentrations of alkali and alkaline earth elements and non-metals.

[All values are the percent difference from composite sample concentrations listed in [table 11](#). **Vertical or Horizontal variation:** H, horizontal; V, vertical. Abbreviations: I, reported values or replicate measurements are identical within significant figures of the reporting unit]

Site identifier	Sample identifier	Variation	Alkali and alkaline earth elements									
			Barium	Beryllium	Calcium	Cesium	Lithium	Magne-sium	Potas-sium	Rubidium	Sodium	Strontium
LR-1	PW-1B	H	0.8	4.2	13.1	10.6	3.0	9.1	6.7	7.8	2.1	6.3
	PW-1C	H	.5	I	16.8	6.4	3.3	3.7	7.8	9.6	1.4	6.6
LR-2	LR-2A	V	1.9	I	8.0	2.6	2.4	6.1	4.5	2.4	.9	7.2
	LR-2B	V	I	I	9.7	3.9	4.0	2.7	.4	.8	10.0	5.2
LR-3	LR-3A	V	7.3	8.0	.7	4.0	5.7	.8	3.4	2.9	8.6	3.6
	LR-3B	V	9.1	3.8	5.0	5.7	9.4	6.4	9.2	7.9	9.6	6.1
LR-4	PW-4A	H	1.6	4.2	9.1	I	3.1	2.0	.7	4.6	.9	2.5
	PW-4F	H	2.4	12.5	5.7	16.7	2.5	5.6	3.0	1.8	5.1	5.7
LR-5	PW-5A	H	17.1	4.3	20.3	46.4	29.1	6.7	8.9	2.6	18.9	22.6
	PW-5B	H	1.4	17.4	14.7	I	1.4	23.3	11.3	9.8	15.7	16.0
	PW-5D	H	I	8.7	7.4	3.6	2.3	1.1	I	.5	3.8	10.9
LR-6	LR-6A	V	7.0	26.3	7.6	10.0	13.5	1.0	10.9	9.2	12.2	10.0
	LR-6B	V	.2	.2	1.8	.1	1.2	4.5	.1	5.6	.1	.1
LR-7	PW-7E	H	6.2	6.3	1.0	11.1	2.1	13.9	.7	1.2	1.4	8.0
	PW-7F	H	14.7	6.3	2.3	22.2	3.2	27.0	6.9	9.4	5.0	1.7
SA-8	SA-8A	V	7.2	I	14.4	21.6	12.6	8.5	.8	7.7	16.2	18.5
	SA-8B	V	4.6	4.2	3.2	7.8	6.4	5.4	2.0	2.9	5.8	2.6

Site identifier	Sample identifier	Variation	Non-metals	
			Arsenic	Phosphorus
LR-1	PW-1B	H	I	19.3
	PW-1C	H	8.9	1.8
LR-2	LR-2A	V	I	I
	LR-2B	V	13.6	20.0
LR-3	LR-3A	V	13.3	I
	LR-3B	V	7.1	6.3
LR-4	PW-4A	H	6.3	I
	PW-4F	H	6.3	15.9
LR-5	PW-5A	H	37.5	33.3
	PW-5B	H	25.0	8.3
	PW-5D	H	2.5	I
LR-6	LR-6A	V	16.7	16.7
	LR-6B	V	.1	.2
LR-7	PW-7E	H	6.3	6.4
	PW-7F	H	6.3	6.4
SA-8	SA-8A	V	3.2	18.2
	SA-8B	V	24.2	9.1

**Table 13.** Concentrations of metals in composite samples and field replicates.[Concentrations are in microgram per gram. **Abbreviations:** cm, centimeter; PW, pore water. **Symbols:** –, not analyzed; <, less than]

Site identifier	Sample identifier	Sample type	Metals									
			Aluminum	Antimony	Bismuth	Cadmium	Chromium	Cobalt	Copper	Gallium	Iron	Lead
LR-1	LR-1	Composite	66,100	0.8	0.29	.25	45.8	6.8	12.1	16	28,000	15.9
	PW-1B	0–2 cm spent PW	69,200	1.0	.28	.32	53.9	7.7	13.6	17	37,000	17.6
	PW-1C	0–2 cm spent PW	68,500	1.0	.26	.33	56.0	7.3	12.5	17	41,000	16.7
LR-2	LR-2	Composite	83,800	4.2	.81	6.8	101.0	18.8	84.0	22	51,000	247
	LR-2A	0–1 cm	83,900	3.0	.71	4.0	96.6	19.4	63.4	22	52,000	116
	LR-2B	7–10 cm	85,000	4.0	.94	10.5	109.0	19.8	72.5	22	50,000	374
LR-3	LR-3	Composite	76,200	4.2	.66	6.7	101.0	16.3	68.7	19	42,000	413
	LR-3A	0–1 cm	72,200	3.2	.54	4.8	88.9	15.9	55.3	18	42,000	205
	LR-3B	5–6 cm	79,800	4.8	.72	7.8	108.0	16.5	81.7	20	44,000	480
LR-4	LR-4	Composite	69,700	.5	.10	.24	42.1	6.3	12.3	15	20,000	17.9
	PW-4A	0–2 cm spent PW	70,400	.5	.11	.31	40.7	5.7	12.4	15	19,000	20
	PW-4F	0–2 spent PW	68,600	.6	.12	.33	43.6	6.5	15.0	15	21,000	20.4
LR-4A	TM-4AINC	0–2 cm spent tumbled core	79,900	3.4	.51	2.6	76.8	14.1	63.3	18	42,000	112
LR-5	LR-5	Composite	60,800	4.8	.75	3.6	61.3	9.1	68.7	15	32,000	212
	PW-5A	0–2 cm spent PW	60,400	8.0	.68	4.6	69.8	12.5	111	16	40,000	190
	PW-5B	0–2 cm spent PW	54,400	5.9	.44	5.3	59.1	8.9	77.1	13	32,000	276
	PW-5D	0–2 spent PW	61,300	4.1	.38	3.0	58.8	8.7	61.8	14	30,000	180
LR-5A	TM-5AINC	0–2 cm spent tumbled core	66,900	13.5	.38	3.4	68.3	13.8	212.0	16	50,000	167
LR-6	LR-6	Composite	53,000	24.0	.40	4.2	61.7	12.4	281	14	45,000	205
	LR-6A	0–1 cm	60,400	20.1	.30	4.5	81.4	15.0	234	16	49,000	170
	LR-6B	3–4 cm	58,100	34.3	.26	3.4	70.5	15.5	328	16	51,000	159
LR-7	LR-7	Composite	43,200	174	.21	1.4	173.0	64.7	2,660	26	220,000	843
	LR-7R	Composite	43,600	163	.13	1.2	166.0	64.8	2,600	26	220,000	802
	PW-7E	0–2 cm spent PW	43,500	145	.13	1.5	146.0	62.1	2,480	24	200,000	926
	PW-7F	0–2 cmspent PW	44,600	125	.28	1.5	132.0	56.0	2,300	22	190,000	816
SA-8	SA-8	Composite	77,800	1.7	.34	.38	75.2	12.5	24.6	19	35,000	21.1
	SA-8A	0–1 cm	76,700	1.2	.42	.63	79.0	13.5	29.2	20	39,000	22.6
	SA-8B	5–7 cm	77,300	1.1	.35	.41	82.6	12.8	27.8	20	37,000	21.7
	<sup>1</sup> RM 743	0–2 cm	32,400	323	.3	<.003	298	86.8	3,790	33.5	32,400	642

**Table 13.** Concentrations of metals in composite samples and field replicates.—Continued[Concentrations are in microgram per gram. **Abbreviations:** cm, centimeter; PW, porewater. **Symbols:** —, not analyzed; <, less than]

Site identifier	Sample identifier	Sample type	Metals									
			Manganese	Molybdenum	Nickel	Scandium	Silver	Thallium	Titanium	Vanadium	Yttrium	Zinc
LR-1	LR-1	Composite	455	0.31	14.1	9.6	<3	0.7	2,500	70.4	18.7	75
	PW-1B	0–2 spent PW	517	.33	16.3	10.8	<3	.9	3,100	85.5	20.9	109
	PW-1C	0–2 spent PW	542	.32	15.2	10.1	<3	.8	2,800	93.5	19.1	96
LR-2	LR-2	Composite	2,210	1.1	45.3	16.3	<3	1.8	4,300	121	45.8	806
	LR-2A	0–1 cm	3,780	1.6	50.1	16.5	<3	1.2	4,500	125	30.3	580
	LR-2B	7–10 cm	1,180	1.3	44.4	16.4	<3	1.7	4,500	120	51.6	1,220
LR-3	LR-3	Composite	1,510	1.3	41.6	13.2	<3	1.8	3,500	112	47.0	798
	LR-3A	0–1 cm	3,200	1.7	42.0	12.8	<3	1.4	3,400	106	32.9	530
	LR-3B	5–6 cm	1,050	1.3	44.2	14.0	<3	2.2	3,700	118	51.1	985
LR-4	LR-4	Composite	445	.36	15.2	7.0	<3	.6	2,000	64.1	14.7	57
	PW-4A	0–2 spent PW	470	.39	14.6	6.9	<3	.6	1,900	60.7	12.9	65
	PW-4F	0–2 spent PW	492	.45	17.2	7.2	<3	.6	2,000	66.5	13.7	72
LR-4A	TM-4AINC	0–2 spent tumbled core	1,110	1.2	36.8	11.6	<3	.9	3,500	103	23.9	407
LR-5	LR-5	Composite	560	1.8	22.5	8.8	<3	.9	2,700	80.4	26.0	763
	PW-5A	0–2 spent PW	729	2.1	30.0	10.9	<3	.8	2,900	90.0	26.1	954
	PW-5B	0–2 spent PW	536	2.6	23.5	7.9	<3	.9	2,300	75.6	26.1	1,020
	PW-5D	0–2 spent PW	510	1.9	21.8	8.9	<3	.8	2,400	77.5	23.4	663
LR-5A	TM-5AINC	0–2 spent tumbled core	904	4.4	24.2	8.3	<3	.7	2,800	79.7	21.4	2,320
LR-6	LR-6	Composite	844	5.6	18.4	6.8	<3	.6	2,000	67.1	17.8	2,760
	LR-6A	0–1 cm	880	4.8	22.7	8.3	<3	.7	2,700	80.4	20.5	2,250
	LR-6B	3–4 cm	1,030	4.6	19.7	7.9	<3	.7	2,600	77.4	21.3	2,760
LR-7	LR-7	Composite	4,320	35	17.7	8.4	5.4	.2	2,200	80.4	20.9	18,200
	LR-7R	Composite	4,250	35	17.0	8.4	5.1	.2	2,200	80.1	21.2	18,000
	PW-7E	0–2 spent PW	3,850	35	16.8	9.0	4.9	.2	2,300	90.0	21.0	16,500
	PW-7F	0–2 spent PW	3,440	32	15.9	9.8	4.5	.2	2,500	101	21.8	14,400
SA-8	SA-8	Composite	642	.78	28.0	11.9	<3	.7	3,800	85.4	22.9	117
	SA-8A	0–1 cm	857	.61	31.6	13.2	<3	.8	4,300	90.0	26.0	149
	SA-8B	5–7 cm	608	.72	30.4	13.0	<3	.8	4,600	90.4	26.1	115
	<sup>1</sup> RM 743	0–2 cm	5,860	62	25.8	7.0	—	.1	2,530	77.1	22.2	23,000

<sup>1</sup>RM 743 is a sample of unsorted beach sand containing slag that was collected from river mile 743 of the Columbia River on September 13, 2002 and analyzed as part of a previous study (Cox and others, 2005).

**Table 14.** Vertical and horizontal variation of concentrations of metals.[Values are the percent difference from composite sample concentrations listed in [table 13](#). **Vertical or horizontal variation:** H, horizontal, V, vertical.**Abbreviations:** I, reported values or replicate measurements are identical within significant figures of the reporting unit. **Symbols:** —, not applicable]

Site identifier	Sample identifier	Vertical or horizontal variation	Aluminum	Antimony	Bismuth	Cadmium	Chromium	Cobalt	Copper	Gallium	Iron	Lead
LR-1	PW-1B	H	4.7	20.5	3.4	28.0	17.7	13.2	12.4	6.3	32.1	10.7
	PW-1C	H	3.6	15.7	10.3	32.0	22.3	7.4	3.3	6.3	46.4	5.0
LR-2	LR-2A	V	.1	28.6	12.3	41.2	4.4	3.2	24.5	I	2.0	53.0
	LR-2B	V	1.4	4.8	16.0	54.4	7.9	5.3	13.7	I	2.0	51.4
LR-3	LR-3A	V	5.5	31.3	22.2	39.6	13.6	2.5	24.2	5.6	.0	102
	LR-3B	V	9.5	33.3	25.0	38.5	17.7	3.6	32.3	10.0	4.5	57.3
LR-4	PW-4A	H	1.0	14.9	10.0	29.2	3.3	9.5	.8	.0	5.0	11.7
	PW-4F	H	1.6	25.5	20.0	37.5	3.6	3.2	22.0	.0	5.0	14.0
LR-5	PW-5A	H	.7	66.7	9.3	27.8	13.9	37.4	61.6	6.7	25.0	10.4
	PW-5B	H	10.5	22.9	41.3	47.2	3.6	2.2	12.2	13.3	I	30.2
	PW-5D	H	.8	14.6	49.3	16.7	4.1	4.4	10.0	6.7	6.3	15.1
LR-6	LR-6A	V	14.0	16.3	25.0	7.1	31.9	21.0	16.7	14.3	8.9	17.1
	LR-6B	V	.1	.4	.4	.2	.1	.3	.2	.1	.1	.2
LR-7	PW-7E	H	.7	16.7	38.1	7.1	15.6	4.0	6.8	7.7	9.1	9.8
	PW-7F	H	3.2	28.2	33.3	7.1	23.7	13.4	13.5	15.4	13.6	3.2
SA-8	SA-8A	V	1.4	29.4	23.5	65.8	5.1	8.0	18.7	5.3	11.4	7.1
	SA-8B	V	.6	35.3	2.9	7.9	9.8	2.4	13.0	5.3	5.7	2.8

Site identifier	Sample identifier	Vertical or horizontal variation	Manganese	Molybdenum	Nickel	Scandium	Silver	Titanium	Thallium	Vanadium	Yttrium	Zinc
LR-1	PW-1B	H	13.6	6.5	15.6	12.5	—	24.0	20.8	21.4	11.8	44.9
	PW-1C	H	19.1	3.2	7.8	5.2	—	12.0	5.6	32.8	2.1	27.4
LR-2	LR-2A	V	71.0	45.5	10.6	1.2	—	4.7	33.3	3.3	33.8	28.0
	LR-2B	V	46.6	18.2	2.0	.6	—	4.7	5.6	.8	12.7	51.4
LR-3	LR-3A	V	52.8	23.5	1.0	3.1	—	2.9	28.6	5.7	42.9	50.6
	LR-3B	V	204.8	30.8	5.0	8.6	—	8.1	36.4	10.2	35.6	46.2
LR-4	PW-4A	H	5.6	8.3	3.9	1.4	—	5.0	I	5.3	12.2	13.9
	PW-4F	H	10.6	25.0	13.2	2.9	—	.0	I	3.7	6.8	25.3
LR-5	PW-5A	H	30.2	16.7	33.3	23.9	—	7.4	12.8	11.9	.4	25.0
	PW-5B	H	4.3	44.4	4.4	10.2	—	14.8	1.2	6.0	.4	33.7
	PW-5D	H	8.9	5.6	3.1	1.1	—	11.1	8.1	3.6	10.0	13.1
LR-6	LR-6A	V	4.3	14.3	23.4	22.1	—	35.0	6.3	19.8	15.2	18.5
	LR-6B	V	.2	.2	.1	.2	—	.3	.1	.2	.2	I
LR-7	PW-7E	H	10.9	1.4	5.1	7.1	9.1	4.5	I	11.9	.5	9.3
	PW-7F	H	20.4	9.7	10.2	16.7	17.3	13.6	I	25.6	4.3	20.9
SA-8	SA-8A	V	33.5	21.8	12.9	10.9	—	13.2	5.5	5.4	13.5	27.4
	SA-8B	V	5.3	7.7	8.6	9.2	—	21.1	2.7	5.9	14.0	1.7

**Table 15.** Concentrations of lanthanide and actanide elements in composite samples and field replicates.[All concentrations are in micrograms per gram. **Abbreviations:** cm, centimeter; pw, porewater]

Site identifier	Sample identifier	Sample type	Cerium	Lanthanum	Thorium	Uranium
LR-1	LR-1	Composite	82.0	46.3	14.7	3.8
	PW-1B	0–2 cm spent PW	105	51.7	13.9	2.4
	PW-1C	0–2 cm spent PW	100	51.6	17.5	2.9
LR-2	LR-2	Composite	98.4	62.7	15.8	5.2
	LR-2A	0–1 cm	95.1	52.6	15.5	5.3
	LR-2B	7–10 cm	88.8	67.2	14.7	5.2
LR-3	LR-3	Composite	101	68.9	13.8	4.3
	LR-3A	0–1 cm	87.9	59.2	13.8	4.2
	LR-3B	5–6 cm	111	75.1	15.0	4.5
LR-4	LR-4	Composite	57.2	33.2	8.9	2.1
	PW-4A	0–2 cm spent PW	56.0	33.2	8.5	1.4
	PW-4F	0–2 cm spent PW	53.3	30.9	8.3	1.5
LR-4A	TM-4AINC	0–2 cm spent tumbled core	88.1	50.2	13.9	4.2
LR-5	LR-5	Composite	78.1	49.9	10.9	4.0
	PW-5A	0–2 cm spent PW	76.8	48.1	12.7	4.5
	PW-5B	0–2 cm spent PW	65.2	42.9	9.1	4.3
	PW-5D	0–2 cm spent PW	73.8	47.2	11.8	3.7
LR-5A	TM-5AINC	0–2 cm spent tumbled core	76.4	44.6	10.9	4.0
LR-6	LR-6	Composite	68.2	41.8	10.3	4.5
	LR-6A	0–1 cm	71.3	42.8	11.9	5.8
	LR-6B	3–4 cm	85.4	51.9	17.8	5.7
LR-7	LR-7	Composite	48.4	30.6	6.7	4.7
	LR-7R	Composite	51.0	32.2	8.0	4.8
	PW-7E	0–2 cm spent PW	47.6	30.2	6.3	4.3
	PW-7F	0–2 cm spent PW	54.9	35.4	6.9	4.0
SA-8	SA-8	Composite	81.2	44.6	10.9	3.5
	SA-8A	0–1 cm	83.2	45.6	11.8	4.0
	SA-8B	5–7 cm	87.3	47.0	11.2	4.4
	<sup>1</sup> RM 743	0–2 cm	55.2	31.8	9.2	6.4

<sup>1</sup>RM 743 is a sample of unsorted beach sand containing slag that was collected from river mile 743 of the Columbia River on September 13, 2002 and analyzed as part of a previous study (Cox and others, 2005).

**Table 16.** Vertical and horizontal variation of concentrations of lanthanide and actinide elements.

[Values are the percent difference from composite concentrations listed in [table 15](#). **Abbreviations:** I, reported values or replicate measurements are identical within significant figures of the reporting unit; **Variation:** H, horizontal; V, vertical]

Site identifier	Sample identifier	Variation	Cerium	Lanthanum	Thorium	Uranium
LR-1	PW-1B	H	28.0	11.7	5.4	36.8
	PW-1C	H	22.0	11.4	19.0	23.7
LR-2	LR-2A	V	3.4	16.1	1.9	1.9
	LR-2B	V	9.8	7.2	7.0	I
LR-3	LR-3A	V	14.9	16.4	I	2.4
	LR-3B	V	20.8	21.2	8.0	6.7
LR-4	PW-4A	H	2.1	I	4.5	33.3
	PW-4F	H	6.8	6.9	6.7	28.6
LR-5	PW-5A	H	1.7	3.6	16.5	12.5
	PW-5B	H	16.5	14.0	16.5	7.5
	PW-5D	H	5.5	5.4	8.3	7.5
LR-6	LR-6A	V	4.5	2.4	15.5	28.9
	LR-6B	V	.3	.2	.7	.3
LR-7	PW-7E	H	1.7	1.3	6.0	8.5
	PW-7F	H	13.4	15.7	3.0	14.9
SA-8	SA-8A	V	2.5	2.2	8.3	14.3
	SA-8B	V	7.5	5.4	2.8	25.7

**Table 17.** Concentrations of alkali, alkaline earth, non-metals, and actinide elements from selective extraction fractions of composite sediment samples.

[All concentrations are in micrograms per gram. **Step:** Fraction 1 extractant, 0.11M acetic acid; Fraction 2 extractant, 0.5 M hydroxylamine hydrochloride; Fraction 3 extractant, 30 percent hydrogen peroxide followed with 1.0 M ammonium acetate. **Symbol:** <, less than]

Elements														
Site identifier	Step	Alkali and alkaline earth										Non-metal		Actinide
		Barium	Beryl- lium	Calcium	Cesium	Lithium	Magne- sium	Potas- sium	Rubi- dium	Sodium	Stron- tium	Arsenic	Selenium	Uranium
LR-1	Fraction1	13.6	0.03	3,250	< 0.004	< 0.2	230	29.6	0.11	<20	6.9	<0.2	<0.2	0.02
	Fraction2	12.3	.03	1,000	.07	.3	141	25.8	.38	<20	3.8	.8	<0.2	.05
	Fraction3	4.01	.04	202	.06	.8	166	65.4	.44	<20	1.0	<.2	<0.2	.04
	Residual	585	1.3	4,570	3.85	20.8	5,890	<6	83.2	12,200	205	4.1	<0.2	1.08
LR-2	Fraction1	82.5	.2	2,070	.005	.2	354	123	0.37	23.5	15.1	3.2	<0.2	.19
	Fraction2	109	.3	1,980	.25	1.4	658	121	1.46	<20	13.5	4.0	0.2	.75
	Fraction3	15.3	.1	305	.18	3.7	846	119	.90	58.3	3.1	.2	0.7	1.26
	Residual	608	1.2	3,010	4.84	29.8	8,080	20,200	69.6	8,830	124	8.4	<0.2	1.51
LR-3	Fraction1	89.5	.2	1,960	<.004	<.2	315	75.0	0.30	19.1	12.7	.4	<.2	.11
	Fraction2	79.9	.2	2,080	.21	.9	492	78.1	1.23	<20	12.0	3.4	<.2	.62
	Fraction3	15.9	.07	266	.03	2.5	561	92.0	.69	45.9	2.6	<.2	.6	.92
	Residual	721	1.2	5,580	3.59	22.0	7,450	19,500	61.1	13,200	237	3.1	<.2	1.29
LR-4	Fraction1	16.8	.03	2,350	<.004	<.2	420	21.6	.10	<20	8.2	<.2	<.2	.03
	Fraction2	9.96	.04	1,180	.04	.3	160	20.1	.23	<20	5.0	.4	<.2	.09
	Fraction3	3.17	.04	304	.03	.7	188	39.9	.27	19.4	1.4	<.2	<.2	.14
	Residual	734	1.0	8,550	1.26	9.2	3,460	18,300	43.9	19,200	330	.6	<.2	.74
LR-5	Fraction1	48.4	.07	13,100	<.004	.2	6,850	35.5	.17	<20	12.1	.5	<.2	.20
	Fraction2	60.4	.2	5,770	.10	1.0	2,470	23.7	.44	<20	9.9	2	<.2	.49
	Fraction3	27.8	.05	272	.09	2.0	328	50.8	.53	26.8	1.7	<.2	.4	.77
	Residual	816	1.2	6,690	1.91	13.1	4,810	16,500	54.7	12,900	289	3.2	<.2	1.03
LR-6	Fraction1	121	.08	14,100	.006	.6	4,470	147	.49	90.7	27.0	.9	<.2	.34
	Fraction2	124	.07	14,600	.006	.5	4,530	150	.48	26.9	26.2	.8	<.2	.33
	Fraction3	15.6	.06	785	.08	1.2	423	37.7	.44	<20	2.1	.3	.4	1.16
	Residual	819	1.0	8,360	1.34	10.6	4,250	17,700	48.0	14,200	305	5.5	<.2	1.32
LR-7	Fraction1	477	.2	17,500	.09	3.1	1,170	785	2.95	554	95.1	3	.2	1.04
	Fraction2	482	.2	17,600	.08	3.0	1,150	835	2.94	503	91.3	3	<.2	1.01
	Fraction3	454	.3	17,500	.20	3.8	1,420	890	3.78	483	65.8	2	1.2	1.24
	Residual	727	.5	20,200	.55	5.8	1,860	7,200	17.4	5,360	201	5.1	.8	1.28
SA-8	Fraction1	28.7	.1	3,580	<.004	.2	471	74.0	.14	29.5	15.6	.8	<.2	.10
	Fraction2	67.6	.2	3,170	.14	1.4	1,090	116	.62	<20	27.8	2	<.2	.72
	Fraction3	16.0	.06	410	.06	2.4	697	85.0	.41	43.4	7.7	<.2	.4	.71
	Residual	661	1.1	6,320	3.93	22.7	7,120	20,200	63.6	13,500	277	3	<.2	.84
Reporting limit		0.04	0.01	40	0.004	.2	2	6	0.002	20	0.1	0.2	0.2	0.02

**Table 18.** Concentration of metals from selective extraction fractions of composite sediment samples.

[All concentrations are in micrograms per gram. **Extractant:** Fraction 1 extractant, 0.11 M Acetic Acid; Fraction 2 extractant, 0.5M Hydroxylamine hydrochloride; Fraction 3 extractant, 30 percent hydrogen peroxide followed with 1.0 M ammonium acetate. **Abbreviations:** M, molar. **Symbol:** <, less than]

Site identifier	Extractant	Aluminum	Antimony	Bismuth	Cadmium	Chromium	Cobalt	Copper	Gallium	Germanium	Iron
LR-1	Fraction1	29	<0.06	<0.04	0.16	0.3	0.49	0.4	<0.01	<0.01	61
	Fraction2	338	<.06	.05	.06	<.2	.59	1.1	.10	<.01	859
	Fraction3	139	<.06	<.04	.02	2.4	.22	.2	.01	<.01	83
	Residual	29,900	.39	.09	.02	29.3	3.58	7.4	13.7	1.0	18,200
LR-2	Fraction1	96	<.06	<.04	2.44	.4	3.36	10.7	.04	.01	1,580
	Fraction2	2,780	.07	.21	2.86	3.8	3.51	25.4	.50	.04	7,770
	Fraction3	943	<.06	<.04	.73	7.2	1.23	6.0	.10	.02	407
	Residual	25,900	3.08	.35	.11	81.5	7.72	33.7	17.8	1.1	30,500
LR-3	Fraction1	107	<.06	<.04	3.93	.3	2.25	8.4	.03	<.01	94
	Fraction2	2,110	.20	.24	1.76	3.4	3.47	20.1	.53	.04	6,750
	Fraction3	508	<.06	<.04	.24	7.1	.82	5.2	.08	.01	328
	Residual	20,500	1.66	.23	.20	44.5	6.67	27.0	15.4	.70	22,800
LR-4	Fraction1	46	.20	<.04	.11	.3	.46	.80	<.01	<.01	12
	Fraction2	378	<.06	<.04	.04	.3	.54	1.7	.20	<.01	769
	Fraction3	208	<.06	<.04	.02	3.0	.25	.4	.02	<.01	77
	Residual	13,600	.10	.05	.04	68.0	3.87	7.4	12.1	.43	13,400
LR-5	Fraction1	58	.21	<.04	1.89	.6	.80	15.2	<.01	.06	910
	Fraction2	1,300	.25	.16	.73	2.9	1.98	23.0	.40	.05	5,960
	Fraction3	568	.06	<.04	.64	4.5	.64	15.3	.03	<.01	893
	Residual	23,900	2.26	.16	.25	22.7	3.42	11.0	10.9	1.8	15,700
LR-6	Fraction1	404	1.42	<.04	.79	2.2	3.05	18.4	.03	1.2	6,920
	Fraction2	403	1.51	<.04	.80	1.7	3.14	18.8	.03	1.2	7,140
	Fraction3	704	.63	<.04	1.37	4.9	1.07	200	.20	.08	1,730
	Residual	19,100	25.3	0.30	.76	38.6	4.34	16.9	12.6	4.2	18,600
LR-7	Fraction1	1,680	6.01	<.04	.10	8.2	15.3	2.4	1.4	9.1	39,500
	Fraction2	1,660	6.24	<.04	.10	7.7	15.7	2.4	1.4	9.2	40,100
	Fraction3	5,650	4.55	<.04	.34	29.8	13.8	389	3.1	10.3	47,200
	Residual	6,350	23.0	.06	.06	58.6	16.5	1,590	19.6	6.2	73,100
SA-8	Fraction1	36	<.06	<.04	.17	.3	1.80	1.2	<.01	<.01	756
	Fraction2	2,380	<.06	.08	.18	2.4	2.45	4.6	.58	.02	4,010
	Fraction3	508	<.06	<.04	.03	6.3	.90	1.5	.06	.01	335
	Residual	20,800	.36	.17	.03	53.5	6.23	16.3	15.6	.58	23,300
Reporting limit		0.4	0.06	0.04	0.004	0.2	0.004	0.1	0.01	0.01	10

**Table 18.** Concentration of metals from selective extraction fractions of composite sediment samples.—Continued

[All concentrations are in micrograms per gram. **Extractant:** Fraction 1 extractant, 0.11 M Acetic Acid; Fraction 2 extractant, 0.5M Hydroxylamine hydrochloride; Fraction 3 extractant, 30 percent hydrogen peroxide followed with 1.0 M ammonium acetate. **Abbreviations:** M, molar. **Symbol:** <, less than]

Site identifier	Extractant	Lead	Man-ganese	Molyb-denum	Nickel	Silver	Thallium	Vanadium	Zinc
LR-1	Fraction1	0.3	84.7	<0.4	0.3	<0.6	<0.02	0.1	9.6
	Fraction2	4.0	41.0	<.4	.5	<.6	.04	.9	9.9
	Fraction3	.4	8.8	<.4	.6	<.6	<.02	2.2	2.5
	Residual	8.0	131	<.4	11.6	<.6	.50	36.7	37.1
LR-2	Fraction1	21.7	1,180	<.4	3.2	<.6	.07	.9	292
	Fraction2	184	422	<.4	5.1	<.6	.53	10.6	272
	Fraction3	8.8	53.5	<.4	4.3	<.6	.10	1.6	36.0
	Residual	14.5	217	0.87	25.6	.66	.70	91.9	123
LR-3	Fraction1	38.4	777	<.4	2.7	<.6	.05	.1	198
	Fraction2	306	324	<.4	5.3	<.6	.40	7.8	364
	Fraction3	12.5	34.9	<.4	3.4	<.6	.08	3.8	39.9
	Residual	18.6	176	<.4	12.5	<.6	.76	61.4	132
LR-4	Fraction1	.4	80.5	<.4	.6	<.6	<.02	.1	6.7
	Fraction2	4.4	39.4	<.4	.8	<.6	<.02	1.3	6.3
	Fraction3	.3	9.5	<.4	1.0	<.6	<.02	3.4	2.7
	Residual	8.3	145	<.4	38.5	<.6	.4	27.9	31.1
LR-5	Fraction1	30.4	104	<.4	1.1	<.6	.02	.3	187
	Fraction2	145	63.2	<.4	3.0	<.6	.10	7.0	331
	Fraction3	11.2	16.1	<.4	2.2	<.6	.04	.9	118
	Residual	15.5	182	.83	14.5	<.6	.40	45.5	102
LR-6	Fraction1	30.3	280	<.4	.8	<.6	<.02	.5	905
	Fraction2	30.6	289	<.4	.8	<.6	<.02	.4	932
	Fraction3	42.7	36.6	.68	2.7	<.6	.06	1.1	415
	Residual	28.2	238	6.30	3.7	.99	.40	46.6	320
LR-7	Fraction1	19.0	1,190	4.52	.9	<.6	<.02	3.7	4,260
	Fraction2	19.2	1,210	4.53	.9	<.6	<.02	3.6	4,280
	Fraction3	174	1,110	1.22	3.6	<.6	<.02	7.4	4,550
	Residual	216	341	2.31	<.08	3.70	.10	24.1	4,900
SA-8	Fraction1	0.3	182	<.4	2.2	<.6	<.02	1.1	11.6
	Fraction2	9.8	99.6	<.4	3.7	<.6	.04	6.1	22.3
	Fraction3	0.9	25.8	<.4	2.6	<.6	<.02	3.2	5.8
	Residual	8.2	206	.39	21.8	<.6	.50	43.1	57.6
Reporting limit		0.01	0.04	0.4	.08	0.6	0.02	0.1	0.1

**Table 19.** Source of reservoir water, water column properties, and compositing data of porewater samples.

[Abbreviations: temp., temperature; –, not collected or analyzed]

Site identifier	Source of reservoir water	Water column				Porewater samples		Comments
		Surface		Bottom		Number of porewater samples from individual cores	Number of composite porewater samples from multiple cores	
		temp.	pH	temp.	pH			
LR-1	From draining box core	20.1	7.9	19.7	7.9	1	1	Incubation site.
LR-2	From sealed box core	19.0	–	19.5	8.1	3	0	
LR-3	From sealed box core	17.7	8.0	17.8	8.1	4	0	
LR-4	From draining box core	16.8	8.2	16.6	8.1	2	3	
LR-4A	–	–	–	–	–	1	0	
LR-5	–	–	–	–	–	5	0	Incubation site.
LR-5A	Surface water	14.8	8.4	–	–	1	0	
LR-6	From sealed box core	15.2	8.3	–	–	5	0	
LR-7	Surface water	–	–	–	–	0	2	
SA-8	From sealed box core	19.2	–	17.9	–	4	0	

**Table 20.** Concentrations of alkali and alkaline earth elements and non-metals in reservoir water from Lake Roosevelt.[Concentrations are in micrograms per liter unless otherwise indicated. **Abbreviations:** mg/L, milligram per liter. **Symbol:** <, less than]

Site identifier	Sample identifier	Collection method	Alkali and Alkaline Earth Elements									
			Barium	Beryllium	Calcium (mg/L)	Cesium	Lithium	Magne-sium (mg/L)	Potas-sium (mg/L)	Sodium (mg/L)	Rubi-dium	Stron-tium
Samples taken from a draining box corer												
LR-1	LR-1	Draining	30.5	<0.05	18.5	<0.02	5	4.3	0.92	1.75	0.82	98
LR-4	LR-4	Draining	26.7	<.05	18.2	<.02	<4.5	4.26	.73	1.77	.89	93
Samples taken from water overlying sediment from a box corer that sealed												
LR-2	LR-2	Sealed	24.8	<0.05	18.0	<0.02	<4.5	4.38	0.72	1.75	0.89	98
LR-3	LR-3	Sealed	25.4	<.05	17.7	<.02	<4.5	4.36	.72	1.74	.89	94
LR-4A	LR-4A	Sealed	26.2	<.05	16.9	<.02	<4.5	4.01	.83	1.59	.95	87
LR-6	LR-6	Sealed	33.8	<.05	16.7	<.02	<4.5	4.13	.82	1.89	.82	75
SA-8	SA-8	Sealed	25.3	<.05	17.8	<.02	<4.5	4.34	.84	2.20	.80	100
Samples taken near lake surface from side of boat												
LR-5A	LR-5A	Surface	28.2	<0.05	17.1	<0.02	<4.5	4.12	0.8	1.64	0.86	83
LR-7	LR-7	Surface	34.9	< .05	17.3	< .02	<4.5	4.25	.76	1.87	.80	75
	LR-7R	Surface	33.8	< .05	16.7	< .02	<4.5	4.13	.82	1.89	.82	75
Reporting limit			1	0.05	1.0	0.02	4.5	0.05	0.15	0.5	0.05	2.5
Site identifier	Sample identifier	Collection method	Non-Metals					Silica (mg/L)	Sulfate (mg/L)			
			Arsenic	Phos-phorus (mg/L)	Selenium							
Samples taken from a draining box corer												
LR-1	LR1	Draining	<1	<0.05	<5	3.5	25					
LR-4	LR-4	Draining	<1	<.05	<5	3.2	<10					
Samples taken from water overlying sediment from a box corer that sealed												
LR-2	LR-2	Sealed	<1	<0.05	<5	3.0	<10					
LR-3	LR-3	Sealed	<1	<.05	<5	2.9	<10					
LR-4A	LR-4A	Sealed	<1	<.05	<5	2.5	31					
LR-6	LR-6	Sealed	<1	<.05	<5	3.1	31					
SA-8	SA-8	Sealed	2	<.05	<5	4.9	14					
Samples taken near lake surface from side of boat												
LR-5A	LR-5A	Surface	<1	<0.05	<5	2.9	33					
LR-7	LR-7	Surface	< 1	<.05	<5	3.3	25					
	LR-7R	Surface	< 1	.05	<5	3.1	31					
Reporting limit			1	.05	5	1	10					

**Table 21.** Concentrations of metals in reservoir water from Lake Roosevelt.[All concentrations are in micrograms per liter. **Abbreviations:** OTL, outlier (see [table 8](#)). **Symbol:** <, less than]

Site identifier	Sample identifier	Collection method	Metals												
			Aluminum	Antimony	Bismuth	Cadmium	Chromium	Cobalt	Copper	Gallium	Germanium	Iron	Lead	Manganese	Molybdenum
Samples taken from a draining box corer															
LR-1	LR-1	Draining	18.7	<0.3	<0.2	<0.1	<5	<0.1	1.3	<0.05	<0.25	<250	0.5	17.8	<2
LR-4	LR-4	Draining	17.9	<.3	<.2	<.1	<5	<.1	<.5	<.05	<.25	<250	<.25	13.5	<2
Samples taken from water overlying sediment from a box corer that sealed															
LR-2	LR-2	Sealed	13.5	<0.3	<0.2	<0.1	<5	<0.1	<0.5	<0.05	<0.25	<250	0.94	<5	<2
LR-3	LR-3	Sealed	15.0	<.3	<.2	<.1	<5	.37	<.5	<.05	<.25	<250	2.4	<5	<2
LR-4A	LR-4A	Sealed	15.2	<.3	<.2	<.1	<5	.11	.84	<.05	<.25	<250	.64	<5	<2
LR-6	LR-6	Sealed	12.9	<.3	<.2	<.1	<5	<.1	1.0	<.05	<.25	<250	.3	<5	<2
SA-8	SA-8	Sealed	21.5	.4	<.2	<.1	<5	<.1	<.5	<.05	<.25	<250	5.5	13.1	<2
Samples taken near lake surface from side of boat															
LR-5A	LR-5A	Surface	11.5	.46	<0.2	<0.1	<5	<0.1	0.51	<0.05	<0.25	<250	<0.25	<5	<2
LR-7	LR-7	Surface	10.4	<.3	<.2	.11	<5	.11	.99	<.05	<.25	<250	<.25	<5	<2
	LR-7R	Surface	12.9	.3	<.2	<.1	<5	<.1	1.01	<.05	<.25	<250	.3	<5	2
Reporting limit			10	0.3	0.2	0.1	5	0.1	0.5	0.05	0.25	250	0.25	5	2

Site identifier	Sample identifier	Collection method	Metals											
			Nickel	Niobium	Scandium	Silver	Tantalum	Thallium	Titanium	Tungsten	Vanadium	Yttrium	Zinc	Zirconium
Samples taken from a draining box corer														
LR-1	LR-1	Draining	OTL	<1	<3	<15	<0.1	<0.2	<2.5	<0.5	<2.5	<0.05	<2.5	<1
LR-4	LR-4	Draining	<0.4	<1	<3	<15	<.1	<.2	<2.5	<.5	<2.5	<0.05	<2.5	<1
Samples taken from water overlying sediment from a box corer that sealed														
LR-2	LR-2	Sealed	<0.4	<1	<3	<15	<0.1	<0.2	<2.5	<0.5	<2.5	<0.05	2.8	<1
LR-3	LR-3	Sealed	<0.4	<1	<3	<15	<.1	<.2	<2.5	<.5	<2.5	<0.05	<2.5	<1
LR-4A	LR-4A	Sealed	0.6	<1	<3	<15	<.1	<.2	<2.5	<.5	<2.5	<0.05	3.6	<1
LR-6	LR-6	Sealed	<0.4	<1	<3	<15	<.1	<.2	<2.5	<.5	<2.5	<0.05	<2.5	<1
SA-8	SA-8	Sealed	<0.4	<1	<3	<15	<.1	<.2	<2.5	<.5	<2.5	<0.05	3.6	<1
Samples taken near lake surface from side of boat														
LR-5A	LR-5A	Surface	<0.4	<1	<3	<15	<0.1	<0.2	<2.5	<0.5	<2.5	<0.05	<2.5	<1
LR-7	LR-7	Surface	<0.4	<1	<3	<15	<.1	<.2	<2.5	<.5	<2.5	<0.05	<2.5	<1
	LR-7R	Surface	<0.4	<1	<3	<15	<.1	<.2	<2.5	<.5	<2.5	<0.05	<2.5	<1
Reporting limit			0.4	1	3	15	0.1	0.2	2.5	0.5	2.5	0.05	2.5	1

**Table 22.** Concentrations of lanthanide and actinide elements in reservoir water from Lake Roosevelt.[All concentrations are in microgram per liter; **Symbol:** <, less than]

Site identifier	Sample identifier	Collected method units	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium
Samples taken from a draining box corer										
LR-1	LR-1	Draining	<0.05	<0.04	<0.025	<0.025	<0.025	<0.025	<0.1	<0.5
LR-4	LR-4	Draining	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
Samples taken from water overlying sediment from a box corer that sealed										
LR-2	LR-2	Sealed	<0.05	<0.04	<0.025	<0.025	<0.025	<.025	<0.1	<0.5
LR-3	LR-3	Sealed	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
LR-4A	LR-4A	Sealed	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
LR-6	LR-6	Sealed	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
SA-8	SA-8	Sealed	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
Samples taken near lake surface from side of boat										
LR-5A	LR-5A	Surface	<0.05	<0.04	<0.025	<0.025	<0.025	<0.025	<0.1	<0.5
LR-7	LR-7	Surface	<.05	<.04	.03	<.025	<.025	<.025	<.1	<.5
	LR-7R	Surface	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
Reporting limit			0.05	0.04	0.025	0.025	0.025	.025	0.1	0.5
Site identifier	Sample identifier	Collected method units	Neodymium	Praseodymium	Samarium	Terbium	Thorium	Thulium	Uranium	Ytterbium
Samples taken from a draining box corer										
LR-1	LR-1	Draining	<0.05	<0.05	<0.09	<0.1	<1	<0.045	<0.5	<0.025
LR-4	LR-4	Draining	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
Samples taken from water overlying sediment from a box corer that sealed										
LR-2	LR-2	Sealed	<0.05	<0.05	<0.09	<0.1	<1	<0.045	<0.5	<0.025
LR-3	LR-3	Sealed	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
LR-4A	LR-4A	Sealed	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
LR-6	LR-6	Sealed	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
SA-8	SA-8	Sealed	<.05	<.05	<.09	<.1	<1	<.045	.57	<.025
Samples taken near lake surface from side of boat										
LR-5A	LR-5A	Surface	<0.05	<0.05	<0.09	<0.1	<1	<0.045	<0.5	<0.025
LR-7	LR-7	Surface	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
	LR-7R	Surface	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
Reporting limit			0.05	0.05	0.09	0.1	1	0.045	0.5	0.025

**Table 23.** Concentrations of alkali and alkaline earth elements and non-metals in the porewater of Lake Roosevelt sediments.

[Concentrations are in micrograms per liter unless otherwise indicated. **Identifier:** multiple letter (A through I) indicates compositing of samples from multiple sediment cores; PW, porewater. **Abbreviations:** mg/L, milligrams per liter. **Symbol:** <, less than]

Site identifier	Number of cores	Identifier	Alkali and alkaline earth elements									
			Barium	Beryllium	Calcium (mg/L)	Cesium	Lithium	Magnesium (mg/L)	Potassium (mg/L)	Rubidium	Sodium (mg/L)	Strontium
LR-1	1	B	54.6	<0.05	23.7	0.05	<4.5	5.17	1.61	2.76	2.85	114
	3	ACD	65.1	<.05	32.0	.03	<4.5	5.66	1.44	2.08	2.29	130
LR-2	1	B	60.0	<.05	20.3	.06	<4.5	4.84	1.51	2.88	2.05	106
	1	C	57.5	<.05	20.2	.06	<4.5	4.94	1.58	3.12	2.03	111
	1	D	53.5	<.05	18.3	.06	<4.5	4.34	1.41	2.84	1.99	102
LR-3	1	A	70.0	<.05	17.0	.04	<4.5	4.16	1.10	2.40	1.79	92.0
	1	C	51.6	<.05	17.5	<.02	<4.5	4.38	1.06	1.60	1.90	90.9
	1	D	57.8	<.05	18.3	.03	<4.5	4.39	1.18	2.32	1.98	97.3
	1	E	43.1	<.05	16.3	.03	<4.5	3.89	1.04	1.70	1.81	90.0
LR-4	2	DF	50.4	<.05	29.6	<.02	<4.5	5.43	1.14	1.58	2.00	142
	1	I	44.3	<.05	25.1	.03	5	5.05	1.05	1.31	1.90	118
	2	BE	57.2	<.05	27.3	.03	<4.5	4.99	1.35	2.25	2.09	129
	1	G	55.3	<.05	25.0	.03	<4.5	4.73	1.18	2.24	1.96	122
	2	CH	46.8	<.05	25.4	<.02	<4.5	4.68	1.10	1.69	1.87	121
LR-4A	1	PW	74.0	<.05	17.8	.07	<4.5	4.02	1.23	2.40	1.97	98.6
LR-5	1	A	193	<.05	46.2	.05	<4.5	5.42	2.15	4.47	2.38	150
	1	B	138	<.05	36.5	.04	5.2	8.05	1.60	3.00	2.48	156
	1	C	129	<.05	46.2	.07	<4.5	9.72	1.68	3.69	2.55	176
	1	D	141	<.05	36.6	.07	5.4	8.34	1.72	3.63	2.42	149
	1	E	126	<.05	46.2	.08	<4.5	10.4	1.74	4.29	2.33	186
LR-5A	1	PW	77.7	<.05	29.4	.07	<4.5	7.29	1.29	2.54	2.45	144
LR-6	1	A	78	<.05	19.2	.06	<4.5	3.74	1.25	2.05	2.02	91.0
	1	B	104	<.05	25.4	.10	<4.5	4.30	1.74	3.21	2.23	117
	1	C	117	<.05	26.4	.10	5.2	4.61	2.00	3.62	2.30	118
	1	D	96.4	<.05	26.2	.08	5.2	4.76	1.82	3.23	2.28	120
	1	E	103	<.05	23.3	.08	<4.5	4.38	1.74	2.74	2.26	117
LR-7	4	CEDF	43.6	.06	20.5	.04	<4.5	4.35	1.05	1.40	2.39	101
	2	AB	44.0	<.05	20.8	<.02	<4.5	4.49	1.04	1.25	2.17	97.0
SA-8	1	A	27.2	<.05	27.2	<.02	7.3	6.36	1.54	1.53	2.90	148
	1	B	38.8	<.05	22.8	.03	4.8	5.54	1.34	1.93	2.26	119
	1	C	26.4	<.05	25.4	.03	<4.5	5.95	1.47	1.90	2.64	131
	1	D	31.3	<.05	22.9	.04	<4.5	5.47	1.40	1.72	2.66	120
Reporting limit			1	0.05	1.0	0.02	4.5	0.02	0.50	0.05	0.05	2.5

**Table 23.** Concentrations of alkali and alkaline earth elements and non-metals in the porewater of Lake Roosevelt sediments.—Continued

[Concentrations are in micrograms per liter unless otherwise indicated. **Identifier:** multiple letter (A through I) indicates compositing of samples from multiple sediment cores; PW, porewater. **Abbreviations:** mg/L, milligram per liter. **Symbol:** <, less than]

Site identifier	Number of cores	Identifier	Non-metals				
			Arsenic	Phosphorus (mg/L)	Selenium	Silica (mg/L)	Sulfate (mg/L)
LR-1	1	B	2.0	0.09	<5	15.4	17
	3	ACD	2.0	.1	<5	10.6	12
LR-2	1	B	13.3	.2	<5	34.4	<10
	1	C	11.5	.3	<5	39.7	<10
	1	D	5.7	.1	<5	31.4	<10
LR-3	1	A	3.5	.06	<5	28.3	<10
	1	C	2.0	<.05	<5	23.0	<10
	1	D	<1	<.05	<5	23.9	<10
	1	E	<1	<.05	<5	23.6	<10
LR-4	2	DF	2.0	.09	<5	19.3	<10
	1	I	2.0	.07	<5	17.9	<10
	2	BE	3.2	.1	<5	23.1	<10
	1	G	2.0	.07	<5	21.7	<10
	2	CH	2.0	.1	<5	19.2	<10
LR-4A	1	PW	6.2	.09	<5	34.6	<10
LR-5	1	A	5.7	<.05	<5	27.2	<10
	1	B	3.2	<.05	<5	24.2	12
	1	C	8.4	<.05	<5	31.8	15
	1	D	7.3	.09	<5	34.5	<10
	1	E	12.2	.1	<5	33.4	<10
LR-5A	1	PW	7.6	.3	<5	35.8	<10
LR-6	1	A	3.0	<.05	<5	18.0	<10
	1	B	4.0	<.05	<5	25.1	<10
	1	C	4.2	.06	<5	21.7	<10
	1	D	3.3	<.05	<5	21.3	<10
	1	E	3.3	.06	<5	20.2	<10
LR-7	4	CEDF	<1	.06	<5	5.4	11
	2	AB	<1	<.05	<5	4.6	<10
SA-8	1	A	22.5	1.5	<5	34.5	<10
	1	B	17.8	0.3	<5	32.6	<10
	1	C	27.4	1.8	<5	34.3	<10
	1	D	19.1	1.0	<5	32.2	<10
Reporting limit			1	0.05	5	1	10

**Table 24.** Concentrations of metals in the porewater of Lake Roosevelt sediments.

[All concentrations are in micrograms per liter. **Identifier:** multiple letter (A through I) indicates compositing of samples from multiple sediment cores; PW, porewater. **Symbol:** <, less than]

Site identifier	Number of cores	Identifier	Metals												
			Aluminum	Antimony	Bismuth	Cadmium	Chromium	Cobalt	Copper	Gallium	Germanium	Iron	Lead	Manganese	Molybdenum
LR-1	1	B	174	0.5	<0.2	0.37	<5	0.21	3.2	0.08	<0.25	<250	1.6	11.6	<2
	3	ACD	139	.6	<.2	.31	<5	.11	1.6	.06	<.25	<250	.9	16.6	<2
LR-2	1	B	39.8	1.1	<.2	<.1	<5	1.26	8.5	.10	<.25	<250	3.0	4,080	2.7
	1	C	40.4	.5	<.2	<.1	<5	.68	.7	.10	<.25	<250	.8	6,500	3.7
	1	D	34.0	.7	<.2	<.1	<5	.67	.8	.10	<.25	<250	.6	5,580	2.8
LR-3	1	A	72.9	.6	<.2	.21	<5	.70	1.0	.08	<.25	<250	6.6	3,410	<2
	1	C	114	.5	<.2	.39	<5	.23	1.8	<.05	<.25	<250	5.2	473	<2
	1	D	100	.6	<.2	.97	<5	.31	2.9	.07	<.25	<250	2.4	1,270	<2
	1	E	67.4	.3	<.2	.56	<5	.12	1.9	<.05	<.25	<250	1.0	428	<2
LR-4	2	DF	167	.4	<.2	<.1	<5	<.1	1.1	<.05	<.25	<250	.8	20.7	<2
	1	I	206	.4	<.2	<.1	<5	<.1	1.4	<.05	<.25	<250	1.0	6.8	<2
	2	BE	210	.7	<.2	.18	<5	.18	1.9	<.05	<.25	<250	1.5	280	<2
	1	G	196	.7	<.2	.20	<5	.17	2.1	.08	<.25	<250	1.4	102	<2
	2	CH	164	.3	<.2	.14	<5	1.54	1.6	.06	<.25	<250	1.2	197	<2
LR-4A	1	PW	51.3	.4	<.2	<.1	<5	.84	<.5	.09	<.25	266	1.9	3,240	<2
LR-5	1	A	18.3	2.9	<.2	<.1	<5	.25	1.0	<.05	<.25	<250	4.4	506	10.5
	1	B	20.7	.5	<.2	.13	<5	.55	.5	<.05	<.25	<250	2.0	922	2.6
	1	C	32.3	.6	<.2	<.1	<5	.59	1.1	<.05	<.25	750	3.2	958	2.9
	1	D	17.4	.3	<.2	<.1	<5	.68	.6	<.05	<.25	3,680	4.8	1,160	2.4
	1	E	14.6	.5	<.2	.11	<5	1.01	<.5	<.05	<.25	1,360	1.2	1,360	5.3
LR-5A	1	PW	21.9	<.3	<.2	<.1	<5	.55	<.5	<.05	<.25	3,020	2.4	1,210	<2
LR-6	1	A	22.0	1.9	<.2	<.1	<5	.45	.9	<.05	.45	<250	2.6	396	<2
	1	B	28.2	2.5	<.2	<.1	<5	.62	1.9	<.05	.64	<250	5.3	407	2.8
	1	C	31.3	3.1	<.2	<.1	<5	.51	3.4	.06	.82	<250	4.9	423	3.0
	1	D	19.0	1.4	<.2	<.1	<5	.48	1.4	<.05	.42	<250	3.2	538	5.2
	1	E	26.9	3.0	<.2	<.1	<5	1.09	3.0	<.05	.54	<250	5.8	353	2.4
LR-7	4	CEDF	54.3	7.3	<.2	<.1	<5	.18	8.1	.10	<.25	<250	2.7	<5	<2
	2	AB	47.2	4.4	<.2	<.1	<5	<.1	10.2	.09	<.25	<250	2.6	<5	<2
SA-8	2	A	95.8	<.3	<.2	<.1	<5	.63	<.5	.06	<.25	2,150	.3	910	<2
	1	B	130	.3	<.2	<.1	<5	.80	<.5	.08	<.25	<250	.4	2,200	2.7
	1	C	240	<.3	<.2	<.1	<5	.63	<.5	.08	<.25	1,430	.7	1,010	<2
	1	D	446	<.3	<.2	<.1	<5	.62	.6	.10	<.25	1,040	1.0	803	<2
Reporting limit			15	0.3	0.2	0.1	5	0.10	0.5	0.05	0.25	250	0.25	5	2

**Table 24.** Concentrations of metals in the porewater of Lake Roosevelt sediments.—Continued

[All concentrations are in micrograms per liter. **Identifier:** multiple letter (A through I) indicates compositing of samples from multiple sediment cores; pw, porewater. **Symbol:** <, less than]

Site No.	Number of cores	Identifier	Metals											
			Nickel	Niobium	Scandium	Silver	Tantalum	Thallium	Titanium	Tungsten	Vanadium	Yttrium	Zinc	Zirconium
LR-1	1	B	6.0	<1	<3	<15	0.2	<0.2	4.2	<0.5	2.7	0.21	16.8	<1
	3	ACD	2.9	<1	<3	<15	<1	<2	3.4	<.5	<2.5	.21	11.0	<1
LR-2	1	B	1.7	<1	3.5	<15	<1	<2	<2.5	1.3	<2.5	.12	6.1	<1
	1	C	1.3	<1	4.5	<15	<1	<2	<2.5	.6	<2.5	.13	6.8	<1
	1	D	.9	<1	<3	<15	<1	<2	<2.5	<.5	<2.5	.10	7.5	<1
LR-3	1	A	0.9	<1	<3	<15	<1	<2	<2.5	<.5	<2.5	.20	8.9	<1
	1	C	6.0	<1	<3	<15	<1	<2	<2.5	<.5	<2.5	.23	13.4	<1
	1	D	1.0	<1	<3	<15	<1	<2	<2.5	<.5	<2.5	.24	15.3	<1
	1	E	.7	<1	<3	<15	<1	<2	<2.5	<.5	<2.5	.14	13.3	<1
LR-4	2	DF	0.5	<1	<3	<15	<1	<2	2.9	<.5	<2.5	.20	<2.5	<1
	1	I	<.4	<1	<3	<15	<1	<2	5.4	<.5	<2.5	.26	2.8	<1
	2	BE	.8	<1	<3	<15	<1	<2	4.3	<.5	7.4	.33	<2.5	<1
	1	G	.6	<1	<3	<15	<1	<2	3.4	<.5	3.7	.27	3.2	<1
	2	CH	.5	<1	<3	<15	<1	<2	<2.5	<.5	<2.5	.28	2.7	<1
LR-4A		PW	0.6	<1	3.1	<15	<1	<2	<2.5	<.5	<2.5	.19	4.7	<1
LR-5	1	A	<0.4	<1	<3	<15	<1	<2	<2.5	<.5	<2.5	.07	4.4	<1
	1	B	1.2	<1	<3	<15	<1	<2	<2.5	<.5	<2.5	.09	16.6	<1
	1	C	.9	<1	<3	<15	<1	<2	<2.5	<.5	<2.5	.17	14.8	<1
	1	D	1.0	<1	<3	<15	<1	<2	<2.5	<.5	<2.5	.14	10.6	<1
	1	E	1.4	<1	3.1	<15	<1	<2	<2.5	.5	<2.5	.20	7.0	<1
LR-5A	1	PW	0.5	<1	3.3	<15	<1	<2	<2.5	.6	<2.5	.16	3.3	<1
LR-6	1	A	<0.4	<1	<3	<15	<1	<2	<2.5	<.5	<2.5	<.05	7.3	<1
	1	B	.7	<1	<3	<15	<1	<2	<2.5	.5	<2.5	.10	21.3	<1
	1	C	<.4	<1	<3	<15	<1	<2	<2.5	1.1	<2.5	.10	16.0	<1
	1	D	<.4	<1	<3	<15	<1	<2	<2.5	.6	<2.5	.06	12.5	<1
	1	E	.5	<1	<3	<15	<1	<2	<2.5	.8	<2.5	.09	11.6	<1
LR-7	4	CEDF	5.5	<1	<3	<15	<1	<2	<2.5	<.5	<2.5	.08	14.8	<1
	2	AB	<.4	<1	<3	<15	<1	<2	<2.5	<.5	<2.5	.07	22.8	<1
SA-8	2	A	0.8	<1	<3	<15	<1	<2	3.1	<.5	<2.5	.17	<2.5	<1
	1	B	2.4	<1	<3	<15	<1	<2	6.1	<.5	<2.5	.19	3.1	<1
	1	C	2.8	<1	3.2	<15	<1	<2	6.0	<.5	<2.5	.30	5.5	<1
	1	D	.8	<1	<3	<15	<1	<2	9.7	<.5	<2.5	.43	4.4	<1
Reporting limit			0.4	1	3	15	0.1	0.2	2.5	0.5	2.5	0.05	2.5	1

**Table 25.** Concentrations of lanthanide and actinide elements in the porewater of Lake Roosevelt sediments.

[All concentrations are in micrograms per liter. **Identifier:** multiple letter (A through I) indicates compositing of samples from multiple sediment cores; PW, porewater. **Symbol:** <, less than]

Site identifier	Number of cores	Identifier	Cerium	Dysprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium
LR-1	1	B	0.39	<0.04	<0.025	<0.025	0.03	<0.025	0.2	<0.5
	3	ACD	.36	<.04	<.025	<.025	.03	<.025	.2	<.5
LR-2	1	B	.11	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	1	C	.14	<.04	<.025	<.025	.04	<.025	.1	<.5
	1	D	.12	<.04	<.025	<.025	<.025	<.025	<.1	<.5
LR-3	1	A	.22	<.04	<.025	<.025	.04	<.025	.2	<.5
	1	C	.21	.06	<.025	<.025	.04	<.025	.3	<.5
	1	D	.26	<.04	<.025	<.025	.06	<.025	.3	<.5
	1	E	.14	<.04	<.025	<.025	<.025	<.025	.1	<.5
LR-4	2	DF	.39	<.04	<.025	<.025	<.025	<.025	.3	<.5
	1	I	.48	<.04	<.025	<.025	.08	<.025	.3	<.5
	2	BE	.83	.08	0.053	<.025	.10	<.025	.5	<.5
	1	G	.63	.09	0.03	<.025	.06	<.025	.4	<.5
	2	CH	.64	.06	<.025	<.025	.09	<.025	.4	<.5
LR-4A	1	PW	.38	<.04	<.025	<.025	.07	<.025	.3	<.5
LR-5	1	A	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	1	B	.08	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	1	C	.14	<.04	<.025	<.025	<.025	<.025	.1	<.5
	1	D	.08	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	1	E	.09	<.04	<.025	<.025	<.025	<.025	<.1	<.5
LR-5A	1	PW	.19	<.04	<.025	<.025	.03	<.025	.1	<.5
LR-6	1	A	.07	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	1	B	.15	<.04	<.025	.03	<.025	<.025	<.1	<.5
	1	C	.15	<.04	<.025	.04	<.025	<.025	<.1	<.5
	1	D	.07	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	1	E	.14	<.04	<.025	<.025	<.025	<.025	.1	<.5
LR-7	4	CEDF	.12	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	2	AB	.24	<.04	<.025	<.025	.03	<.025	.2	<.5
SA-8	2	A	.33	.06	<.025	<.025	.04	<.025	.2	<.5
	1	B	.40	.05	<.025	<.025	.06	<.025	.2	<.5
	1	C	.63	<.04	.03	<.025	.09	<.025	.3	<.5
	1	D	1.07	.09	.051	.03	.07	<.025	.6	<.5
Reporting limit			0.05	0.04	0.025	0.025	0.025	0.025	0.1	0.5

**Table 25.** Concentrations of lanthanide and actinide elements in the porewater of Lake Roosevelt sediments.—Continued

[All concentrations are in micrograms per liter. **Identifier:** multiple letter (A through I) indicates compositing of samples from multiple sediment cores; PW, porewater. **Symbol:** <, less than]

Site identifier	Number of cores	Identifier	Neodymium	Praseodymium	Samarium	Terbium	Thorium	Thulium	Uranium	Ytterbium
LR-1	1	B	0.18	<0.05	<0.09	<0.1	<1	<0.045	<0.5	<0.025
	3	ACD	.20	.06	<.09	<.1	<1	<.045	.6	.03
LR-2	1	B	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
	1	C	<.05	<.05	<.09	<.1	<1	<.045	.5	.05
	1	D	<.05	<.05	<.09	<.1	<1	<.045	<.5	.04
LR-3	1	A	.16	<.05	<.09	<.1	<1	<.045	<.5	.03
	1	C	.24	<.05	<.09	<.1	<1	<.045	<.5	<.025
	1	D	.21	<.05	<.09	<.1	<1	<.045	<.5	.03
	1	E	.08	<.05	<.09	<.1	<1	<.045	<.5	<.025
LR-4	2	DF	.16	.06	<.09	<.1	<1	<.045	.9	.04
	1	I	.24	.08	<.09	<.1	<1	<.045	.6	.06
	2	BE	.44	.11	0.10	<.1	<1	<.045	.6	.05
	1	G	.37	.10	<.09	<.1	<1	<.045	<.5	.05
	2	CH	.26	.09	<.09	<.1	<1	<.045	<.5	.04
LR-4A		PW	.23	.06	<.09	<.1	<1	<.045	<.5	.05
LR-5	1	A	<.05	<.05	<.09	<.1	<1	<.045	3.1	<.025
	1	B	<.05	<.05	<.09	<.1	<1	<.045	.9	<.025
	1	C	.11	<.05	<.09	<.1	<1	<.045	1.4	.03
	1	D	.06	<.05	<.09	<.1	<1	<.045	.6	<.025
	1	E	.12	<.05	<.09	<.1	<1	<.045	1.6	.04
LR-5A	1	PW	.09	<.05	<.09	<.1	<1	<.045	<.5	.03
LR-6	1	A	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
	1	B	.10	<.05	<.09	<.1	<1	<.045	<.5	.03
	1	C	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
	1	D	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
	1	E	.08	<.05	<.09	<.1	<1	<.045	<.5	<.025
LR-7	4	CEDF	.06	<.05	<.09	<.1	<1	<.045	<.5	<.025
	2	AB	.09	<.05	<.09	<.1	<1	<.045	<.5	<.025
SA-8	2	A	.16	<.05	<.09	<.1	<1	<.045	<.5	<.025
	1	B	.27	<.05	<.09	<.1	<1	<.045	.5	<.025
	1	C	.37	.09	<.09	<.1	<1	<.045	<.5	.03
	1	D	.55	.16	.19	<.1	<1	<.045	<.5	.05
Reporting limit			0.05	0.05	0.09	0.1	1	0.045	0.5	.025

**Table 26.** Description of incubation experiments using plastic acrylic core liners.

[Dissolved organic carbon from porewaters was analyzed from lower portion of the core (2 cm to bottom) at end of incubation experiment. Cross-sectional area of plastic acrylic core liners: 33.3 square centimeters. **Abbreviations:** cm, centimeter; mg/L, milligrams per liter; mL, milliliter. **Symbols:** —, not analyzed]

Site identifier	Collection and construction details	Thickness of sediment (cm)	Volume of water (mL)	pH of reservoir water	Replacement water	Dissolved organic carbon (mg/L)	Core conditions at end of incubation experiment
LR-2	Intact sediment-water interface	9.7	164	7.67	From sealed core	32	0.5-cm fluffy brown surface layer over gray sediments.
LR-3	Intact sediment-water interface	8.1	377	7.76	From sealed core	19	Abundant macrofauna, localized black reduced zone 2-3 cm deep. Small amount of water may have leaked out bottom during experiment; spotty brown coloring on core liner below 3 cm.
LR-4A	Intact sediment-water interface	12.3	226	7.54	From sealed core	27	Brownish gray surface layer 0.1-cm thick; spotty brown coloring on core liner below 4 cm. Zooplankton present.
LR-5A	Added surface water to 6.6-cm diameter core with no overlying water	6.2	174	7.9	Site surface water	119	Surface brown layer 0.5- to 1.5-cm thick with oxidation on core liner. Gray silt layer from surface layer to 4.2 cm. Coarse grit material 4.7 to 6.2 cm.
LR-6	Intact sediment-water interface	5.2	214	7.82	From sealed core	44	Gray fluff layer 1 cm thick with brown coloring on core liner over gray material. Red oxidation film 2-3 cm on core liner. Coarse grit material 4.2 to 5.2 cm.
LR-7	Collected sediment in 4.4-cm diameter core liner and dropped contents into pre-sealed 6.6 cm diameter core liner and added surface water	3.0	183	7.84	Site surface water	15	No fluff layer.
LR-7R	Collected sediment in 4.4-cm diameter core liner and dropped contents into pre-sealed 6.6 cm diameter core liner and added surface water core liner not filled—5 cm of air above water	4.0	142	7.88	Site surface water	—	No fluff layer.
SA-8	Intact sediment-water interface	8.6	382	7.62	Overlying water from <sup>1</sup> LR-2	25	0.4-cm brown layer over brownish gray. Three burrow holes present.

<sup>1</sup>No replacement water collected at SA-8 site, and replacement water from nearby site LR-2 was used.

**Table 27.** Concentrations of alkali and alkaline earth elements and non-metals in water from incubation experiments using sediment cores from Lake Roosevelt.[All concentrations in micrograms per liter unless otherwise indicated. **Duration:** time since beginning of experiment; R, replicate. **Symbol:** <, less than]

Site identifier	Sample identifier	Collection			Alkali and alkaline earth elements									
		Date	Time	Duration (days)	Barium	Beryllium	Calcium (mg/L)	Cesium	Lithium	Magnesium (mg/L)	Potassium (mg/L)	Rubidium	Sodium (mg/L)	Strontium
LR-2	LR-2INC0	09-24-04	1917	0.05	25.7	<0.05	16.9	<0.02	<4.5	4.0	0.87	1.18	1.56	95
	LR-2INC2	09-26-04	2006	2.09	25.8	<.05	18.4	<.02	4.7	4.3	.87	1.19	1.56	100
	LR-2INC4	09-28-04	1020	3.68	26.0	<.05	18.6	<.02	<4.5	4.5	.91	1.34	1.62	103
	LR-2INC8	10-02-04	1330	7.81	26.7	<.05	19.7	<.02	<4.5	4.6	1.26	1.36	1.65	105
	LR-2INC18A	10-12-04	1040	17.69	26.9	<.05	20.9	<.02	<4.5	4.9	1.24	1.23	1.91	106
	LR-2INC18B	10-12-04	1042	R	25.7	<.05	20.2	<.02	<4.5	4.9	1.12	1.27	1.81	105
	LR-2INC40	11-03-04	1600	39.92	27.6	<.05	23.3	.06	<4.5	5.5	1.56	3.13	2.26	120
Site identifier	Sample identifier	Collection			Non-metals									
		Date	Time	Duration (days)	Arsenic	Phosphorus (mg/L)	Selenium	Silica (mg/L)	Sulfate (mg/L)					
LR-2	LR-2INC0	09-24-04	1917	0.05	<1	<0.05	<5	6.3	27					
	LR-2INC2	09-26-04	2006	2.09	<1	<.05	<5	14.1	22					
	LR-2INC4	09-28-04	1020	3.68	<1	<.05	<5	19.1	21					
	LR-2INC8	10-02-04	1330	7.81	2	.06	<5	27.1	21					
	LR-2INC18A	10-12-04	1040	17.69	<1	.07	<5	36.4	25					
	LR-2INC18B	10-12-04	1042	R	2	.06	<5	35.7	27					
	LR-2INC40	11-03-04	1600	39.92	2	.07	<5	45.0	25					
Site identifier	Sample identifier	Collection			Alkali and alkaline earth elements									
		Date	Time	Duration (days)	Barium	Beryllium	Calcium (mg/L)	Cesium	Lithium	Magnesium (mg/L)	Potassium (mg/L)	Rubidium	Sodium (mg/L)	Strontium
LR-3	LR-3INC0	09-23-04	1530	0.06	26.9	<0.05	16.2	<0.02	<4.5	4.0	0.76	0.90	1.53	87
	LR-3INC2	09-25-04	1825	2.18	31.4	<.05	16.8	.03	<4.5	4.1	.86	1.65	1.53	92
	LR-3INC4	09-27-04	1115	3.89	32.4	<.05	16.7	.04	<4.5	4.2	.84	2.18	1.62	92
	LR-3INC9	10-02-04	1315	8.97	33.9	<.05	19.3	<.02	<4.5	4.6	1.06	2.46	1.63	101
	LR-3INC19A	10-12-04	1050	18.87	31.4	<.05	22.2	<.02	<4.5	5.3	1.08	1.92	1.73	113
	LR-3INC19B	10-12-04	1052	R	31.9	<.05	22.9	<.02	<4.5	5.5	1.08	1.88	1.68	116
	LR-3INC41	11-03-04	1610	41.09	18.8	<.05	28.5	.06	<4.5	6.5	1.50	4.00	1.9	138
Site identifier	Sample identifier	Collection			Non-metals									
		Date	Time	Duration (days)	Arsenic	Phosphorus (mg/L)	Selenium	Silica (mg/L)	Sulfate (mg/L)					
LR-3	LR-3INC0	09-23-04	1530	0.06	<1	<0.05	<5	2.9	27					
	LR-3INC2	09-25-04	1825	2.18	<1	<.05	<5	5.6	26					
	LR-3INC4	09-27-04	1115	3.89	<1	<.05	<5	8.1	23					
	LR-3INC9	10-02-04	1315	8.97	<1	<.05	<5	16.4	24					
	LR-3INC19A	10-12-04	1050	18.87	<1	.08	<5	26.4	22					
	LR-3INC19B	10-12-04	1052	R	<1	.08	<5	26.5	26					
	LR-3INC41	11-03-04	1610	41.09	<1	.08	<5	37.6	29					

**Table 27.** Concentrations of alkali and alkaline earth elements and non-metals in water from incubation experiments using sediment cores from Lake Roosevelt.—Continued[All concentrations in micrograms per liter unless otherwise indicated. **Duration:** time since beginning of experiment; R, replicate. **Symbol:** <, less than]

Site identifier	Sample identifier	Collection			Alkali and alkaline earth elements									
		Date	Time	Duration (days)	Barium	Beryllium	Calcium (mg/L)	Cesium	Lithium	Magnesium (mg/L)	Potassium (mg/L)	Rubidium	Sodium (mg/L)	Strontium
LR-4A	LR-4AINC0	09-25-04	1910	0.13	32.6	<0.05	17.4	0.05	<4.5	4.1	0.86	1.42	1.73	93
	LR-4AINC2	09-27-04	1905	2.12	39.2	<.05	18.9	.05	<4.5	4.4	1.06	2.20	1.74	98
	LR-4AINC4	09-29-04	1710	4.04	44.2	<.05	21.0	.07	<4.5	4.8	1.28	2.65	1.81	108
	LR-4AINC9	10-04-04	1730	9.06	51.1	<.05	26.5	.08	<4.5	5.8	1.41	2.94	1.83	137
	LR-4AINC17B	10-12-04	1100	16.79	34.6	<.05	28.2	.08	<4.5	6.4	1.53	3.06	2.05	144
	LR-4AINC17A	10-12-04	1101	R	30.2	<.05	29.7	.08	<4.5	6.4	1.68	3.02	1.92	144
	LR-4AINC39	11-03-04	1620	39.01	40.0	<.05	24.7	.12	<4.5	5.9	1.67	3.16	2.07	118

Site identifier	Sample identifier	Collection			Non-metals				
		Date	Time	Duration (days)	Arsenic	Phosphorus (mg/L)	Selenium	Silica (mg/L)	Sulfate (mg/L)
LR-4A	LR-4AINC0	09-25-04	1910	0.13	<1	<0.05	<5	6.0	26
	LR-4AINC2	09-27-04	1905	2.12	<1	.08	<5	12.2	25
	LR-4AINC4	09-29-04	1710	4.04	<1	.07	<5	17.1	18
	LR-4AINC9	10-04-04	1730	9.06	4.7	.08	<5	28.2	22
	LR-4AINC17A	10-12-04	1100	16.79	7.7	.10	<5	36.6	14
	LR-4AINC17B	10-12-04	1101	R	7.2	.10	<5	36.6	21
	LR-4AINC39	11-03-04	1620	39.01	<1	.10	<5	45.8	22

Site identifier	Sample identifier	Collection			Alkali and alkaline earth elements									
		Date	Time	Duration (days)	Barium	Beryllium	Calcium (mg/L)	Cesium	Lithium	Magnesium (mg/L)	Potassium (mg/L)	Rubidium	Sodium (mg/L)	Strontium
LR-5A	LR-5AINC0	09-26-04	2146	0.09	40.4	<.005	17.2	<0.02	<4.5	4.1	0.90	1.17	1.76	85
	LR-5AINC2	09-28-04	2210	2.11	56.6	<.05	21.8	.07	<4.5	4.8	1.28	2.08	1.86	105
	LR-5AINC4	09-30-04	0819	3.53	68.6	<.05	26.2	.09	<4.5	5.6	1.44	2.61	1.94	126
	LR-5AINC8	10-04-04	1745	7.93	88.2	<.05	35.8	.13	<4.5	7.5	1.76	3.26	2.31	172
	LR-5AINC19B	10-15-04	1240	18.72	96.0	<.05	40.5	.14	<4.5	8.3	1.96	3.37	2.50	191
	LR-5AINC38	11-03-04	1630	37.88	93.2	<.05	44.1	.14	<4.5	8.9	2.32	3.51	3.09	207

Site identifier	Sample identifier	Collection			Non-metals				
		Date	Time	Duration (days)	Arsenic	Phosphorus (mg/L)	Selenium	Silica (mg/L)	Sulfate (mg/L)
LR-5A	LR-5AINC0	09-26-04	2146	0.09	<1	<0.05	<5	4.5	32
	LR-5AINC2	09-28-04	2210	2.11	<1	<.05	<5	10.1	28
	LR-5AINC4	09-30-04	0819	3.53	<1	<.05	<5	13.8	29
	LR-5AINC8	10-04-04	1745	7.93	<1	<.05	<5	18.3	27
	LR-5AINC19B	10-15-04	1240	18.72	<1	<.05	<5	18.9	24
	LR-5AINC38	11-03-04	1630	37.88	<1	<.05	<5	22.1	17

**Table 27.** Concentrations of alkali and alkaline earth elements and non-metals in water from incubation experiments using sediment cores from Lake Roosevelt.—Continued[All concentrations in micrograms per liter unless otherwise indicated. **Duration:** time since beginning of experiment; R, replicate. **Symbol:** <, less than]

Site identifier	Sample identifier	Collection			Alkali and alkaline earth elements									
		Date	Time	Duration (days)	Barium	Beryllium	Calcium (mg/L)	Cesium	Lithium	Magnesium (mg/L)	Potassium (mg/L)	Rubidium	Sodium (mg/L)	Strontium
LR-6	LR-6INC0	09-27-04	1910	0.11	43.2	<0.05	18.1	<0.02	<4.5	4.1	0.97	1.20	1.87	83
	LR-6INC2	09-29-04	1730	2.04	60.0	<.05	22.0	.03	<4.5	4.8	1.43	2.58	1.98	106
	LR-6INC5	10-02-04	1340	4.88	68.1	<.05	26.3	.06	<4.5	5.4	1.57	2.77	2.11	121
	LR-6INC8	10-04-04	1530	6.96	76.2	<.05	31.5	<.02	<4.5	6.5	1.88	2.44	2.52	144
	LR-6INC18A	10-15-04	1250	17.85	75.4	<.05	34.2	<.02	<4.5	6.6	1.90	2.03	2.56	154
	LR-6INC18B	10-15-04	1251	R	76.7	<.05	35.3	<.02	<4.5	6.7	1.96	2.12	2.61	156
	LR-6INC37	11-03-04	1640	37.01	84.2	<.05	39.5	<.02	<4.5	7.1	2.26	2.15	3.11	175

Site identifier	Sample identifier	Collection			Non-metals				
		Date	Time	Duration (days)	Arsenic	Phosphorus (mg/L)	Selenium	Silica (mg/L)	Sulfate (mg/L)
LR-6	LR-6INC0	09-27-04	1910	0.11	<1	0<.05	<5	4.4	36
	LR-6INC2	09-29-04	1730	2.04	<1	<.05	<5	8.7	31
	LR-6INC5	10-02-04	1340	4.88	<1	<.05	<5	12.9	26
	LR-6INC8	10-04-04	1530	6.96	<1	<.05	<5	16.8	40
	LR-6INC18A	10-15-04	1250	17.85	<1	<.05	<5	18.6	30
	LR-6INC18A	10-15-04	1251	R	<1	<.05	<5	18.9	41
	LR-6INC37	11-03-04	1640	37.01	<1	<.05	<5	21.3	34

Site identifier	Sample identifier	Collection			Alkali and alkaline earth elements									
		Date	Time	Duration (days)	Barium	Beryllium	Calcium (mg/L)	Cesium	Lithium	Magnesium (mg/L)	Potassium (mg/L)	Rubidium	Sodium (mg/L)	Strontium
LR-7	LR-7AINC0	09-28-04	2130	0.08	36.0	<0.05	17.3	<0.02	<4.5	4.2	0.84	1.15	1.90	80
	LR-7AINC2	09-30-04	0830	1.53	38.4	<.05	18.6	<.02	<4.5	4.3	.88	1.24	1.82	88
	LR-7AINC4	10-02-04	1345	3.75	40.2	<.05	18.5	<.02	<4.5	4.4	.81	1.20	1.87	93
	LR-7AINC8	10-06-04	0840	7.54	39.5	<.05	19.8	<.02	<4.5	4.5	.86	1.24	1.88	99
	LR-7AINC17A	10-15-04	1310	16.73	43.7	<.05	21.7	.03	<4.5	5.1	.88	1.27	1.96	111
	LR-7AINC17B	10-15-04	1311	R	42.7	<.05	22.2	<.02	<4.5	5.0	.86	1.23	1.89	107
	LR-7AINC36	11-03-04	1650	35.88	46.8	<.05	25.1	<.02	<4.5	5.7	.98	1.26	1.99	122

Site identifier	Sample identifier	Collection			Non-metals				
		Date	Time	Duration (days)	Arsenic	Phosphorus (mg/L)	Selenium	Silica (mg/L)	Sulfate (mg/L)
LR-7	LR-7AINC0	09-28-04	2130	0.08	<1	<0.05	<5	3.6	29
	LR-7AINC2	09-30-04	0830	1.53	<1	<.05	<5	3.9	30
	LR-7AINC4	10-02-04	1345	3.75	<1	<.05	<5	4.1	27
	LR-7AINC8	10-06-04	0840	7.54	<1	<.05	<5	4.4	32
	LR-7AINC17A	10-15-04	1310	16.73	<1	<.05	<5	4.9	36
	LR-7AINC17B	10-15-04	1311	R	<1	<.05	<5	4.7	31
	LR-7AINC36	11-03-04	1650	35.88	<1	<.05	<5	5.1	36

**Table 27.** Concentrations of alkali and alkaline earth elements and non-metals in water from incubation experiments using sediment cores from Lake Roosevelt.—Continued[All concentrations in micrograms per liter unless otherwise indicated. **Duration:** time since beginning of experiment; R, replicate. **Symbol:** <, less than]

Site identifier	Sample identifier	Collection			Alkali and alkaline earth elements									
		Date	Time	Duration (days)	Barium	Beryllium	Calcium (mg/L)	Cesium	Lithium	Magnesium (mg/L)	Potassium (mg/L)	Rubidium	Sodium (mg/L)	Strontium
LR-7	LR-7RINC0	09-28-04	2150	0.07	33.7	<0.05	17.3	0.03	<4.5	3.8	1.18	1.74	1.87	79
	LR-7RINC2	09-30-04	0835	1.52	39.0	<.05	19.5	<.02	<4.5	4.0	1.24	1.51	1.83	87
	LR-7RINC4	10-02-04	1350	3.74	40.3	<.05	21.0	<.02	<4.5	4.2	1.30	1.46	1.88	93
	LR-7RINC8	10-06-04	0850	7.53	40.5	<.05	21.6	<.02	<4.5	4.4	1.25	1.35	1.91	97
	LR-7RINC17A	10-15-04	1315	16.71	43.8	<.05	24.3	<.02	<4.5	4.9	1.33	1.32	2.06	108
	LR-7RINC17B	10-15-04	1316	R	42.9	<.05	25.2	<.02	<4.5	4.9	1.33	1.46	2.03	108
	LR-7RINC36	11-03-04	1700	35.87	47.8	<.05	29.8	<.02	<4.5	5.7	1.45	1.42	2.26	124
Site identifier	Sample identifier	Collection			Non-metals									
		Date	Time	Duration (days)	Arsenic	Phosphorus (mg/L)	Selenium	Silica (mg/L)	Sulfate (mg/L)					
LR-7	LR-7RINC0	09-28-04	2150	0.07	<1	<0.05	<5	4.1	24					
	LR-7RINC2	09-30-04	0835	1.52	<1	<.05	<5	4.9	27					
	LR-7RINC4	10-02-04	1350	3.74	<1	<.05	<5	5.6	34					
	LR-7RINC8	10-06-04	0850	7.53	<1	<.05	<5	5.9	28					
	LR-7RINC17A	10-15-04	1315	16.71	<1	<.05	<5	6.6	29					
	LR-7RINC17B	10-15-04	1316	R	<1	<.05	<5	6.5	29					
	LR-7RINC36	11-03-04	1700	35.87	2	<.05	<5	7.2	37					
Site identifier	Sample identifier	Collection			Alkali and alkaline earth elements									
		Date	Time	Duration (days)	Barium	Beryllium	Calcium (mg/L)	Cesium	Lithium	Magnesium (mg/L)	Potassium (mg/L)	Rubidium	Sodium (mg/L)	Strontium
SA-8	SA-8INC0	09-22-04	2100	0.16	25.7	<0.05	15.5	<0.02	<4.5	3.9	0.76	0.83	1.69	91
	SA-8INC2	09-24-04	1710	2.00	32.5	<.05	17.5	<.02	<4.5	4.2	.84	1.12	1.75	100
	SA-8INC4	09-26-04	1120	3.76	33.6	<.05	17.1	<.02	<4.5	4.2	.89	1.35	1.77	102
	SA-8INC8	09-30-04	0815	7.63	32.5	<.05	17.3	<.02	<4.5	4.1	1.37	1.46	2.00	97
	SA-8INC20A	10-12-04	1020	19.72	29.1	<.05	19.0	<.02	<4.5	4.6	1.39	1.00	2.06	104
	SA-8INC20B	10-12-04	1021	R	30.4	<.05	20.2	<.02	<4.5	4.8	1.45	0.98	2.12	109
	SA-8INC42	11-03-04	1710	42.00	27.9	<.05	24.1	<.02	<4.5	5.6	1.37	1.03	2.27	126
Site identifier	Sample identifier	Collection			Non-metals									
		Date	Time	Duration (days)	Arsenic	Phosphorus (mg/L)	Selenium	Silica (mg/L)	Sulfate (mg/L)					
SA-8	SA-8INC0	09-22-04	2100	0.16	<1	<0.05	<5	4.0	21					
	SA-8INC2	09-24-04	1710	2.00	<1	<.05	<5	6.0	28					
	SA-8INC4	09-26-04	1120	3.76	<1	<.05	<5	8.0	26					
	SA-8INC8	09-30-04	0815	7.63	<1	<.05	<5	12.2	30					
	SA-8INC20A	10-12-04	1020	19.72	<1	.07	<5	19.8	28					
	SA-8INC20B	10-12-04	1021	R	<1	.08	<5	20.8	31					
	SA-8INC42	11-03-04	1710	42.00	2.0	.10	<5	30.3	27					

**Table 28.** Concentrations of metals in water from incubation experiments using sediment cores from Lake Roosevelt.

[All concentrations are in micrograms per liter. **Duration:** time since beginning of experiment; R, replicate. **Abbreviations:** OTL, outlier (see table 8); com, contaminated. **Symbols:** <, less than]

Site identifier	Sample identifier	Collection			Aluminum	Antimony	Bismuth	Cadmium	Chromium	Cobalt	Copper	Gallium	Germanium
		Date	Time	Duration (days)									
LR-2	LR-2INC0	09-24-04	1917	0.05	19.7	<0.3	<0.2	<0.1	<5	<0.1	1.0	<0.05	<0.25
	LR-2INC2	09-26-04	2006	2.09	22.0	<.3	<.2	<.1	<5	<.1	1.4	<.05	<.25
	LR-2INC4	09-28-04	1020	3.68	22.5	<.3	<.2	<.1	<5	<.1	1.8	<.05	<.25
	LR-2INC8	10-02-04	1330	7.81	35.1	<.3	<.2	<.1	<5	<.1	2.3	<.05	<.25
	LR-2INC18A	10-12-04	1040	17.69	27.0	<.3	<.2	<.1	<5	<.1	3.2	<.05	<.25
	LR-2INC18B	10-12-04	1042	R	29.0	<.3	<.2	<.1	<5	<.1	3.3	<.05	<.25
	LR-2INC40	11-03-04	1600	39.92	12.7	<.3	<.2	<.1	<5	<.1	4.5	<.05	<.25

Site identifier	Sample identifier	Collection			Iron	Lead	Manganese	Molybdenum	Nickel	Niobium	Scandium	Selenium	Silver
		Date	Time	Duration (days)									
LR-2	LR-2INC0	09-24-04	1917	0.05	<250	0.4	62	<2	<0.4	<1	<3	<5	<15
	LR-2INC2	09-26-04	2006	2.09	<250	<.25	72	<2	<.4	<1	<3	<5	<15
	LR-2INC4	09-28-04	1020	3.68	<250	<.25	112	<2	.6	<1	<3	<5	<15
	LR-2INC8	10-02-04	1330	7.81	<250	<.25	60	<2	<.4	<1	4	<5	<15
	LR-2INC18A	10-12-04	1040	17.69	<250	<.25	20	<2	<.4	<1	6	<5	<15
	LR-2INC18B	10-12-04	1042	R	<250	<.25	25	<2	.6	<1	6	<5	<15
	LR-2INC40	11-03-04	1600	39.92	<250	<.25	6	<2	.6	<1	7	<5	<15

Site identifier	Sample identifier	Collection			Tantalum	Thallium	Titanium	Tungsten	Vanadium	Yttrium	Zinc	Zirconium
		Date	Time	Duration (days)								
LR-2	LR-2INC0	09-24-04	1917	0.05	<0.1	<0.2	<2.5	<0.5	<2.5	<0.05	<3.3	<1
	LR-2INC2	09-26-04	2006	2.09	<.1	<.2	<2.5	<.5	<2.5	<.05	<3.3	<1
	LR-2INC4	09-28-04	1020	3.68	<.1	<.2	<2.5	<.5	<2.5	<.05	<3.3	<1
	LR-2INC8	10-02-04	1330	7.81	<.1	<.2	<2.5	<.5	<2.5	<.05	<3.3	<1
	LR-2INC18A	10-12-04	1040	17.69	<.1	<.2	<2.5	<.5	<2.5	<.05	<3.3	<1
	LR-2INC18B	10-12-04	1042	R	<.1	<.2	<2.5	<.5	<2.5	.06	<3.3	<1
	LR-2INC40	11-03-04	1600	39.92	<.1	<.2	<2.5	<.5	<2.5	.06	<3.3	<1

**Table 28.** Concentrations of metals in water from incubation experiments using sediment cores from Lake Roosevelt.—Continued

[All concentrations are in microgram per liter. **Duration:** time since beginning of experiment; R, replicate. **Abbreviations:** OTL, outlier (see table 8); com, contaminated. **Symbols:** <, less than]

Site identifier	Sample identifier	Collection			Aluminum	Antimony	Bismuth	Cadmium	Chromium	Cobalt	Copper	Gallium	Germanium
		Date	Time	Duration (days)									
LR-3	LR-3INC0	09-23-04	1530	0.06	12.6	<0.3	<0.2	<0.1	<5	<0.1	0.6	<0.05	<0.25
	LR-3INC2	09-25-04	1825	2.18	10.8	<.3	<.2	<.1	<5	<.1	.9	<.05	<.25
	LR-3INC4	09-27-04	1115	3.89	10.6	<.3	<.2	<.1	<5	<.1	1.0	<.05	<.25
	LR-3INC9	10-02-04	1315	8.97	10.8	<.3	<.2	<.1	<5	.26	1.3	<.05	<.25
	LR-3INC19A	10-12-04	1050	18.87	<10	<.3	<.2	<.1	<5	<.1	1.6	<.05	<.25
	LR-3INC19B	10-12-04	1052	R	<10	<.3	<.2	<.1	<5	<.1	1.9	<.05	<.25
	LR-3INC41	11-03-04	1610	41.09	<10	<.3	<.2	.31	<5	<.1	2.1	<.05	<.25

Site identifier	Sample identifier	Collection			Iron	Lead	Manganese	Molybdenum	Nickel	Niobium	Scandium	Selenium	Silver
		Date	Time	Duration (days)									
LR-3	LR-3INC0	09-23-04	1530	0.06	<250	0.7	8	<2	<0.4	<1	<3	<5	<15
	LR-3INC2	09-25-04	1825	2.18	<250	.4	<5	<2	<.4	<1	<3	<5	<15
	LR-3INC4	09-27-04	1115	3.89	<250	<.25	<5	<2	<.4	<1	<3	<5	<15
	LR-3INC9	10-02-04	1315	8.97	<250	<.25	<5	<2	<.4	<1	<3	<5	<15
	LR-3INC19A	10-12-04	1050	18.87	<250	<.25	<5	2.6	<.4	<1	4	<5	<15
	LR-3INC19B	10-12-04	1052	R	<250	<.25	<5	2.6	<.4	<1	4	<5	<15
	LR-3INC41	11-03-04	1610	41.09	<250	<.25	1,280	6.5	.9	<1	6	<5	<15

Site identifier	Sample identifier	Collection			Tantalum	Thallium	Titanium	Tungsten	Vanadium	Yttrium	Zinc	Zirconium
		Date	Time	Duration (days)								
LR-3	LR-3INC0	09-23-04	1530	0.06	<0.1	<0.2	<2.5	<0.5	<2.5	<0.05	<3.3	<1
	LR-3INC2	09-25-04	1825	2.18	<.1	<.2	<2.5	<.5	<2.5	<.05	9.9	<1
	LR-3INC4	09-27-04	1115	3.89	<.1	<.2	<2.5	<.5	<2.5	<.05	<3.3	<1
	LR-3INC9	10-02-04	1315	8.97	<.1	<.2	<2.5	<.5	<2.5	<.05	4.3	<1
	LR-3INC19A	10-12-04	1050	18.87	<.1	<.2	<2.5	<.5	<2.5	<.05	4.2	<1
	LR-3INC19B	10-12-04	1052	R	<.1	<.2	<2.5	<.5	<2.5	<.05	3.3	<1
	LR-3INC41	11-03-04	1610	41.09	<.1	<.2	<2.5	<.5	<2.5	<.05	12	<1

**Table 28.** Concentrations of metals in water from incubation experiments using sediment cores from Lake Roosevelt.—Continued

[All concentrations are in microgram per liter. **Duration:** time since beginning of experiment; R, replicate. **Abbreviations:** OTL, outlier (see table 8); com, contaminated. **Symbols:** <, less than]

Site identifier	Sample identifier	Collection			Alumi-num	Anti-mony	Bis-muth	Cad-mium	Chro-mium	Cobalt	Copper	Gallium	Germa-nium
		Date	Time	Duration (days)									
LR-4A	LR-4AINC0	09-25-04	1910	0.13	17.8	0.4	<0.2	<0.1	<5	<0.1	0.9	<0.05	<0.25
	LR-4AINC2	09-27-04	1905	2.12	19.9	<.3	<.2	<.1	<5	<.1	1.9	<.05	<.25
	LR-4AINC4	09-29-04	1710	4.04	19.0	<.3	<.2	.13	<5	.51	1.7	<.05	<.25
	LR-4AINC9	10-04-04	1730	9.06	<10	<.3	<.2	<.1	<5	.43	.9	.08	<.25
	LR-4AINC17B	10-12-04	1100	16.79	<10	<.3	<.2	<.1	<5	.44	.7	.09	<.25
	LR-4AINC17A	10-12-04	1101	R	<10	<.3	<.2	<.1	<5	.37	.8	.10	<.25
	LR-4AINC39	11-03-04	1620	39.01	13.7	1.0	<.2	<.1	<5	.18	2.4	<.05	<.25
Site identifier	Sample identifier	Collection			Iron	Lead	Man-ganese	Molyb-denum	Nickel	Nio-bium	Scan-dium	Sele-nium	Silver
		Date	Time	Duration (days)									
LR-4A	LR-4AINC0	09-25-04	1910	0.13	<250	1.2	73	<2	<0.4	<1	<3	<5	<15
	LR-4AINC2	09-27-04	1905	2.12	<250	.7	258	<2	<.4	<1	<3	<5	<15
	LR-4AINC4	09-29-04	1710	4.04	<250	.4	1,540	<2	<.4	<1	<3	<5	<15
	LR-4AINC9	10-04-04	1730	9.06	<250	<.25	4,710	2.6	0.8	<1	4	<5	<15
	LR-4AINC17B	10-12-04	1100	16.79	293	<.25	4,960	3.0	1.1	<1	5	<5	<15
	LR-4AINC17A	10-12-04	1101	R	<250	<.25	4,620	2.8	0.7	<1	5	<5	<15
	LR-4AINC39	11-03-04	1620	39.01	<250	.3	716	2.1	1.0	<1	7	<5	<15
Site identifier	Sample identifier	Collection			Tanta-lum	Thal-lium	Tita-nium	Tung-sten	Vana-dium	Yttrium	Zinc	Zirco-nium	
		Date	Time	Duration (days)									
LR-4A	LR-4AINC0	09-25-04	1910	0.13	<0.1	<0.2	<2.5	<0.5	<2.5	<0.05	<3.3	<1	
	LR-4AINC2	09-27-04	1905	2.12	<.1	<.2	<2.5	<.5	<2.5	<.05	<3.3	<1	
	LR-4AINC4	09-29-04	1710	4.04	<.1	<.2	<2.5	<.5	<2.5	<.05	3.8	<1	
	LR-4AINC9	10-04-04	1730	9.06	<.1	<.2	<2.5	<.5	<2.5	<.05	<3.3	<1	
	LR-4AINC17B	10-12-04	1100	16.79	<.1	<.2	<2.5	.84	<2.5	<.05	<3.3	<1	
	LR-4AINC17A	10-12-04	1101	R	<.1	<.2	<2.5	.75	<2.5	<.05	<3.3	<1	
	LR-4AINC39	11-03-04	1620	39.01	<.1	<.2	<2.5	<.5	<2.5	<.05	<3.3	<1	

**Table 28.** Concentrations of metals in water from incubation experiments using sediment cores from Lake Roosevelt.—Continued

[All concentrations are in microgram per liter. **Duration:** time since beginning of experiment; R, replicate. **Abbreviations:** OTL, outlier (see table 8); com, contaminated. **Symbols:** <, less than]

Site identifier	Sample identifier	Collection			Aluminum	Antimony	Bismuth	Cadmium	Chromium	Cobalt	Copper	Gallium	Germanium
		Date	Time	Duration (days)									
LR-5A	LR-5AINC0	09-26-04	2146	0.09	12.1	1.0	<0.2	<0.1	<5	<0.1	0.6	<0.05	<0.25
	LR-5AINC2	09-28-04	2210	2.11	10.7	1.1	<.2	<.1	<5	.37	.9	<.05	<.25
	LR-5AINC4	09-30-04	0819	3.53	<10	.7	<.2	<.1	<5	.39	.8	<.05	<.25
	LR-5AINC8	10-04-04	1745	7.93	<10	.8	<.2	<.1	<5	.33	1.0	<.05	<.25
	LR-5AINC19B	10-15-04	1240	18.72	<10	1.8	<.2	<.1	<5	<.1	1.1	<.05	<.25
	LR-5AINC38	11-03-04	1630	37.88	<10	1.7	<.2	<.1	<5	<.1	1.5	<.05	<.25

Site identifier	Sample identifier	Collection			Iron	Lead	Manganese	Molybdenum	Nickel	Niobium	Scandium	Selenium	Silver
		Date	Time	Duration (days)									
LR-5A	LR-5AINC0	09-26-04	2146	0.09	<250	1.3	23	<2	<0.4	<1	<3	<5	<15
	LR-5AINC2	09-28-04	2210	2.11	324	1.1	191	<2	0.6	<1	<3	<5	<15
	LR-5AINC4	09-30-04	0819	3.53	329	.6	408	2.2	0.7	<1	<3	<5	<15
	LR-5AINC8	10-04-04	1745	7.93	253	1.0	618	4.1	1.0	<1	<3	<5	<15
	LR-5AINC19B	10-15-04	1240	18.72	<250	<.25	114	5.6	0.8	<1	<3	<5	<15
	LR-5AINC38	11-03-04	1630	37.88	<250	<.25	50	7.6	0.6	<1	<3	<5	<15

Site identifier	Sample identifier	Collection			Tantalum	Thallium	Titanium	Tungsten	Vanadium	Yttrium	Zinc	Zirconium
		Date	Time	Duration (days)								
LR-5A	LR-5AINC0	09-26-04	2146	0.09	<0.1	<0.2	<2.5	<0.5	<2.5	<0.05	5.8	<1
	LR-5AINC2	09-28-04	2210	2.11	<.1	<.2	<2.5	<.5	<2.5	<.05	12	<1
	LR-5AINC4	09-30-04	0819	3.53	<.1	<.2	<2.5	<.5	<2.5	<.05	8.9	<1
	LR-5AINC8	10-04-04	1745	7.93	<.1	<.2	<2.5	<.5	<2.5	<.05	6.0	<1
	LR-5AINC19B	10-15-04	1240	18.72	<.1	<.2	<2.5	<.5	<2.5	<.05	<3.3	<1
	LR-5AINC38	11-03-04	1630	37.88	<.1	<.2	<2.5	<.5	<2.5	<.05	<3.3	<1

**Table 28.** Concentrations of metals in water from incubation experiments using sediment cores from Lake Roosevelt.—Continued

[All concentrations are in microgram per liter. **Duration:** time since beginning of experiment; R, replicate. **Abbreviations:** OTL, outlier (see table 8); com, contaminated. **Symbols:** <, less than]

Site identifier	Sample identifier	Collection			Aluminum	Antimony	Bismuth	Cadmium	Chromium	Cobalt	Copper	Gallium	Germanium
		Date	Time	Duration (days)									
LR-6	LR-6INC0	09-27-04	1910	0.11	10.8	1.6	<0.2	<0.1	<5	<0.1	2.0	<0.05	<0.25
	LR-6INC2	09-29-04	1730	2.04	<10	3.1	<.2	<.1	<5	.52	2.1	<.05	<.25
	LR-6INC5	10-02-04	1340	4.88	10.8	3.1	<.2	.15	<5	<.1	3.2	<.05	<.25
	LR-6INC8	10-04-04	1530	6.96	12.0	3.4	<.2	.14	<5	.34	4.2	<.05	<.25
	LR-6INC18A	10-15-04	1250	17.85	10.8	3.5	<.2	.14	<5	<.1	4.9	<.05	<.25
	LR-6INC18A	10-15-04	1251	R	<10	3.6	<.2	.16	<5	<.1	5.0	<.05	<.25
	LR-6INC37	11-03-04	1640	37.01	<10	4.4	<.2	.14	<5	<.1	5.2	<.05	<.25

Site identifier	Sample identifier	Collection			Iron	Lead	Manganese	Molybdenum	Nickel	Niobium	Scandium	Selenium	Silver
		Date	Time	Duration (days)									
LR-6	LR-6INC0	09-27-04	1910	0.11	<250	0.7	10	<2	<0.4	<1	<3	<5	<15
	LR-6INC2	09-29-04	1730	2.04	<250	.3	25	2.2	<.4	<1	<3	<5	<15
	LR-6INC5	10-02-04	1340	4.88	<250	<.25	33	3.5	.5	<1	<3	<5	<15
	LR-6INC8	10-04-04	1530	6.96	<250	OTL	18	4.2	1.0	<1	4	<5	<15
	LR-6INC18A	10-15-04	1250	17.85	<250	<.25	<5	6.1	.6	<1	3	<5	<15
	LR-6INC18A	10-15-04	1251	R	<250	.5	<5	6.2	.6	<1	4	<5	<15
	LR-6INC37	11-03-04	1640	37.01	<250	<.25	<5	12	.6	<1	4	<5	<15

Site identifier	Sample identifier	Collection			Tantalum	Thallium	Titanium	Tungsten	Vanadium	Yttrium	Zinc	Zirconium
		Date	Time	Duration (days)								
LR-6	LR-6INC0	09-27-04	1910	0.11	<0.1	<0.2	<2.5	<0.5	<2.5	<0.05	14	<1
	LR-6INC2	09-29-04	1730	2.04	<.1	<.2	<2.5	<.5	<2.5	<.05	34	<1
	LR-6INC5	10-02-04	1340	4.88	<.1	<.2	<2.5	<.5	<2.5	<.05	37	<1
	LR-6INC8	10-04-04	1530	6.96	<.1	<.2	<2.5	<.5	<2.5	<.05	46	<1
	LR-6INC18A	10-15-04	1250	17.85	<.1	<.2	<2.5	<.5	<2.5	<.05	34	<1
	LR-6INC18A	10-15-04	1251	R	<.1	<.2	<2.5	<.5	<2.5	<.05	35	<1
	LR-6INC37	11-03-04	1640	37.01	<.1	<.2	<2.5	<.5	<2.5	<.05	33	<1

**Table 28.** Concentrations of metals in water from incubation experiments using sediment cores from Lake Roosevelt.—Continued

[All concentrations are in microgram per liter. **Duration:** time since beginning of experiment; R, replicate. **Abbreviations:** OTL, outlier (see [table 8](#)); com, contaminated. **Symbols:** <, less than]

Site identifier	Sample identifier	Collection			Aluminum	Antimony	Bismuth	Cadmium	Chromium	Cobalt	Copper	Gallium	Germanium
		Date	Time	Duration (days)									
LR-7	LR-7AINC0	09-28-04	2130	0.08	26.8	1.1	<0.2	<0.1	<5	0.26	4.3	<0.05	<0.25
	LR-7AINC2	09-30-04	0830	1.53	27.6	2.4	<.2	<.1	<5	<.1	4.4	.10	<.25
	LR-7AINC4	10-02-04	1345	3.75	25.0	4.3	<.2	<.1	<5	OTL	4.1	.08	<.25
	LR-7AINC8	10-06-04	0840	7.54	24.0	6.7	<.2	<.1	<5	<.1	4.3	.09	<.25
	LR-7AINC17A	10-15-04	1310	16.73	26.8	12.6	<.2	.14	<5	<.1	4.9	.10	<.25
	LR-7AINC17B	10-15-04	1311	R	21.3	12.6	<.2	<.1	<5	<.1	4.4	.08	<.25
	LR-7AINC36	11-03-04	1650	35.88	24.3	21.6	<.2	<.1	<5	<.1	4.9	.09	<.25

Site identifier	Sample identifier	Collection			Iron	Lead	Manganese	Molybdenum	Nickel	Niobium	Scandium	Selenium	Silver
		Date	Time	Duration (days)									
LR-7	LR-7AINC0	09-28-04	2130	0.08	<250	0.9	<5	<2	0.5	<1	<3	<5	<15
	LR-7AINC2	09-30-04	0830	1.53	<250	.7	<5	<2	.5	<1	<3	<5	<15
	LR-7AINC4	10-02-04	1345	3.75	<250	.4	<5	<2	<.4	<1	<3	<5	<15
	LR-7AINC8	10-06-04	0840	7.54	<250	.3	<5	<2	<.4	<1	<3	<5	<15
	LR-7AINC17A	10-15-04	1310	16.73	<250	.3	<5	<2	<.4	<1	<3	<5	<15
	LR-7AINC17B	10-15-04	1311	R	<250	<.25	<5	<2	<.4	<1	<3	<5	<15
	LR-7AINC36	11-03-04	1650	35.88	<250	<.25	<5	<2	<.4	<1	<3	<5	<15

Site identifier	Sample identifier	Collection			Tantalum	Thallium	Titanium	Tungsten	Vanadium	Yttrium	Zinc	Zirconium
		Date	Time	Duration (days)								
LR-7	LR-7AINC0	09-28-04	2130	0.08	<0.1	<0.2	<2.5	<0.5	<2.5	<0.05	7.0	<1
	LR-7AINC2	09-30-04	0830	1.53	<.1	<.2	<2.5	<.5	<2.5	<.05	9.5	<1
	LR-7AINC4	10-02-04	1345	3.75	<.1	<.2	<2.5	<.5	<2.5	<.05	8.6	<1
	LR-7AINC8	10-06-04	0840	7.54	<.1	<.2	<2.5	<.5	<2.5	<.05	9.0	<1
	LR-7AINC17A	10-15-04	1310	16.73	<.1	<.2	<2.5	<.5	<2.5	<.05	8.4	<1
	LR-7AINC17B	10-15-04	1311	R	<.1	<.2	<2.5	<.5	<2.5	<.05	8.7	<1
	LR-7AINC36	11-03-04	1650	35.88	<.1	<.2	<2.5	<.5	<2.5	<.05	9.7	<1

**Table 28.** Concentrations of metals in water from incubation experiments using sediment cores from Lake Roosevelt.—Continued

[All concentrations are in microgram per liter. **Duration:** time since beginning of experiment; R, replicate. **Abbreviations:** OTL, outlier (see table 8); com, contaminated. **Symbols:** <, less than]

Site identifier	Sample identifier	Collection			Aluminum	Antimony	Bismuth	Cadmium	Chromium	Cobalt	Copper	Gallium	Germanium
		Date	Time	Duration (days)									
LR-7	LR-7RINC0	09-28-04	2150	0.07	40.8	3.0	<0.2	<0.1	<5	<0.1	10.1	0.22	<0.25
	LR-7RINC2	09-30-04	0835	1.52	28.6	5.8	<.2	<.1	<5	<.1	9.2	.20	.26
	LR-7RINC4	10-02-04	1350	3.74	32.9	8.4	<.2	<.1	<5	<.1	7.7	.20	.27
	LR-7RINC8	10-06-04	0850	7.53	24.0	11.4	<.2	<.1	<5	<.1	5.8	.20	<.25
	LR-7RINC17A	10-15-04	1315	16.71	21.8	17.2	<.2	<.1	<5	<.1	5.3	.10	<.25
	LR-7RINC17B	10-15-04	1316	R	22.4	16.7	<.2	<.1	<5	<.1	5.3	.10	<.25
	LR-7RINC36	11-03-04	1700	35.87	21.2	23.4	<.2	<.1	<5	<.1	4.7	.10	<.25

Site identifier	Sample identifier	Collection			Iron	Lead	Manganese	Molybdenum	Nickel	Niobium	Scandium	Selenium	Silver
		Date	Time	Duration (days)									
LR-7	LR-7RINC0	09-28-04	2150	0.07	<250	1.8	5	<2	<0.4	<1	<3	<5	<15
	LR-7RINC2	09-30-04	0835	1.52	<250	.7	<5	<2	<.4	<1	<3	<5	<15
	LR-7RINC4	10-02-04	1350	3.74	<250	.5	<5	<2	<.4	<1	<3	<5	<15
	LR-7RINC8	10-06-04	0850	7.53	<250	<.25	<5	<2	<.4	<1	<3	<5	<15
	LR-7RINC17A	10-15-04	1315	16.71	<250	<.25	<5	2.6	<.4	<1	<3	<5	<15
	LR-7RINC17B	10-15-04	1316	R	<250	<.25	<5	2.7	<.4	<1	<3	<5	<15
	LR-7RINC36	11-03-04	1700	35.87	<250	<.25	<5	3.9	<.4	<1	<3	<5	<15

Site identifier	Sample identifier	Collection			Tantalum	Thallium	Titanium	Tungsten	Vanadium	Yttrium	Zinc	Zirconium
		Date	Time	Duration (days)								
LR-7	LR-7RINC0	09-28-04	2150	0.07	<0.1	<0.2	<2.5	<0.5	<2.5	<0.05	8.7	<1
	LR-7RINC2	09-30-04	0835	1.52	<.1	<.2	<2.5	<.5	<2.5	<0.05	8.8	<1
	LR-7RINC4	10-02-04	1350	3.74	<.1	<.2	<2.5	<.5	<2.5	<0.05	13	<1
	LR-7RINC8	10-06-04	0850	7.53	<.1	<.2	<2.5	.51	<2.5	<0.05	7.1	<1
	LR-7RINC17A	10-15-04	1315	16.71	<.1	<.2	<2.5	<.5	<2.5	<0.05	7.0	<1
	LR-7RINC17B	10-15-04	1316	R	<.1	<.2	<2.5	.55	<2.5	<0.05	7.2	<1
	LR-7RINC36	11-03-04	1700	35.87	<.1	<.2	<2.5	.62	<2.5	<0.05	7.1	<1

**Table 28.** Concentrations of metals in water from incubation experiments using sediment cores from Lake Roosevelt.—Continued

[All concentrations are in microgram per liter. **Duration:** time since beginning of experiment; R, replicate. **Abbreviations:** OTL, outlier (see table 8); com, contaminated. **Symbols:** <, less than]

Site identifier	Sample identifier	Collection			Aluminum	Antimony	Bismuth	Cadmium	Chromium	Cobalt	Copper	Gallium	Germanium
		Date	Time	Duration (days)									
SA-8	SA-8INC0	09-22-04	2100	0.16	16.5	<0.3	<0.2	<0.1	<5	<0.1	1.2	<0.05	<0.25
	SA-8INC2	09-24-04	1710	2.00	18.7	<.3	<.2	<.1	<5	.16	1.0	<.05	<.25
	SA-8INC4	09-26-04	1120	3.76	12.5	<.3	<.2	<.1	<5	.13	.7	<.05	<.25
	SA-8INC8	09-30-04	0815	7.63	23.9	<.3	<.2	<.1	<5	<.1	1.0	<.05	<.25
	SA-8INC20A	10-12-04	1020	19.72	15.8	<.3	<.2	<.1	<5	<.1	1.1	<.05	<.25
	SA-8INC20B	10-12-04	1021	R	17.4	<.3	<.2	<.1	<5	<.1	1.0	<.05	<.25
	SA-8INC42	11-03-04	1710	42.00	<10	<.3	<.2	<.1	<5	<.1	1.3	<.05	<.25

Site identifier	Sample identifier	Collection			Iron	Lead	Manganese	Molybdenum	Nickel	Niobium	Scandium	Selenium	Silver
		Date	Time	Duration (days)									
SA-8	SA-8INC0	09-22-04	2100	0.16	<250	com	12	<2	<0.4	<1	<3	<5	<15
	SA-8INC2	09-24-04	1710	2.00	<250	0.8	97	<2	<.4	<1	<3	<5	<15
	SA-8INC4	09-26-04	1120	3.76	<250	<.25	139	<2	<.4	<1	<3	<5	<15
	SA-8INC8	09-30-04	0815	7.63	<250	<.25	89	<2	<.4	<1	<3	<5	<15
	SA-8INC20A	10-12-04	1020	19.72	<250	<.25	<5	<2	3.9	<1	<3	<5	<15
	SA-8INC20B	10-12-04	1021	R	<250	<.25	<5	<2	<.4	<1	<3	<5	<15
	SA-8INC42	11-03-04	1710	42.00	<250	<.25	<5	<2	<.4	<1	4	<5	<15

Site identifier	Sample identifier	Collection			Tantalum	Thallium	Titanium	Tungsten	Vanadium	Yttrium	Zinc	Zirconium
		Date	Time	Duration (days)								
SA-8	SA-8INC0	09-22-04	2100	0.16	<0.1	<0.2	<2.5	<0.5	<2.5	<0.05	3.3	<1
	SA-8INC2	09-24-04	1710	2.00	<.1	<.2	<2.5	<.5	<2.5	<.05	3.8	<1
	SA-8INC4	09-26-04	1120	3.76	<.1	<.2	<2.5	<.5	<2.5	<.05	<3.3	<1
	SA-8INC8	09-30-04	0815	7.63	<.1	<.2	<2.5	<.5	<2.5	<.05	<3.3	<1
	SA-8INC20A	10-12-04	1020	19.72	<.1	<.2	<2.5	<.5	<2.5	<.05	4.5	<1
	SA-8INC20B	10-12-04	1021	R	<.1	<.2	<2.5	<.5	<2.5	<.05	<3.3	<1
	SA-8INC42	11-03-04	1710	42.00	<.1	<.2	<2.5	<.5	<2.5	<.05	<3.3	<1

**Table 29.** Concentrations of lanthanide and actinide elements in water from incubation experiments using sediment cores from Lake Roosevelt.

[All concentrations are in micrograms per liter. **Duration:** time since beginning of experiment; R, replicate. **Abbreviations:** com, contaminated. **Symbols:** <, less than]

Site identifier	Sample identifier	Collection			Cerium	Dyprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium
		Date	Time	Duration (days)								
LR-2	LR-2INC0	09-24-04	1917	0.05	<0.05	<0.04	<0.025	<0.025	<0.025	<0.025	<0.1	<0.5
	LR-2INC2	09-26-04	2006	2.09	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-2INC4	09-28-04	1020	3.68	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-2INC8	10-02-04	1330	7.81	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-2INC18A	10-12-04	1040	17.69	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-2INC18B	10-12-04	1042	R	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-2INC40	11-03-04	1600	39.92	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
Site identifier	Sample identifier	Collection			Neodymium	Praseodymium	Samarium	Terbium	Thorium	Thulium	Uranium	Ytterbium
		Date	Time	Duration (days)								
LR-2	LR-2INC0	09-24-04	1917	0.05	<0.05	<0.05	<0.09	<0.1	<1	<0.045	<0.5	0.03
	LR-2INC2	09-26-04	2006	2.09	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
	LR-2INC4	09-28-04	1020	3.68	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
	LR-2INC8	10-02-04	1330	7.81	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
	LR-2INC18A	10-12-04	1040	17.69	<.05	<.05	<.09	<.1	<1	<.045	<.5	.05
	LR-2INC18B	10-12-04	1042	R	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
	LR-2INC40	11-03-04	1600	39.92	<.05	<.05	<.09	<.1	<1	<.045	<.5	.03
Site identifier	Sample identifier	Collection			Cerium	Dyprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium
		Date	Time	Duration (days)								
LR-3	LR-3INC0	09-23-04	1530	0.06	<.05	<0.04	<0.025	<0.025	<0.025	<0.025	<0.1	<0.5
	LR-3INC2	09-25-04	1825	2.18	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-3INC4	09-27-04	1115	3.89	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-3INC9	10-02-04	1315	8.97	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-3INC19A	10-12-04	1050	18.87	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-3INC19B	10-12-04	1052	R	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-3INC41	11-03-04	1610	41.09	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
Site identifier	Sample identifier	Collection			Neodymium	Praseodymium	Samarium	Terbium	Thorium	Thulium	Uranium	Ytterbium
		Date	Time	Duration (days)								
LR-3	LR-3INC0	09-23-04	1530	0.06	<0.05	<0.05	<0.09	<0.1	<1	<0.045	<0.5	<.0025
	LR-3INC2	09-25-04	1825	2.18	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
	LR-3INC4	09-27-04	1115	3.89	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
	LR-3INC9	10-02-04	1315	8.97	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
	LR-3INC19A	10-12-04	1050	18.87	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
	LR-3INC19B	10-12-04	1052	R	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
	LR-3INC41	11-03-04	1610	41.09	<.05	<.05	<.09	<.1	<1	<.045	1.0	<.025

**Table 29.** Concentrations of lanthanide and actinide elements in water from incubation experiments using sediment cores from Lake Roosevelt.—Continued

[All concentrations are in micrograms per liter. **Duration:** time since beginning of experiment; R, replicate. **Abbreviations:** com, contaminated. **Symbols:** <, less than]

Site identifier	Sample identifier	Collection			Cerium	Dyprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium
		Date	Time	Duration (days)								
LR-4A	LR-4AINC0	09-25-04	1910	0.13	<.05	<.04	<.025	<.025	.03	<.025	<.1	<.5
	LR-4AINC2	09-27-04	1905	2.12	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-4AINC4	09-29-04	1710	4.04	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-4AINC9	10-04-04	1730	9.06	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-4AINC17B	10-12-04	1100	16.79	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-4AINC17A	10-12-04	1101	R	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-4AINC39	11-03-04	1620	39.01	.07	<.04	<.025	<.025	<.025	<.025	<.1	<.5
Site identifier	Sample identifier	Collection			Neodymium	Praseodymium	Samarium	Terbium	Thorium	Thulium	Uranium	Ytterbium
		Date	Time	Duration (days)								
LR-4A	LR-4AINC0	09-25-04	1910	0.13	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
	LR-4AINC2	09-27-04	1905	2.12	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
	LR-4AINC4	09-29-04	1710	4.04	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
	LR-4AINC9	10-04-04	1730	9.06	<.05	<.05	<.09	<.1	<1	<.045	1.6	.03
	LR-4AINC17B	10-12-04	1100	16.79	<.05	<.05	<.09	<.1	<1	<.045	1.2	<.025
	LR-4AINC17A	10-12-04	1101	R	<.05	<.05	<.09	<.1	<1	<.045	1.4	<.025
	LR-4AINC39	11-03-04	1620	39.01	<.05	<.05	<.09	<.1	<1	<.045	1.0	<.025
Site identifier	Sample identifier	Collection			Cerium	Dyprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium
		Date	Time	Duration (days)								
LR-5A	LR-5AINC0	09-26-04	2146	0.09	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-5AINC2	09-28-04	2210	2.11	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-5AINC4	09-30-04	0819	3.53	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-5AINC8	10-04-04	1745	7.93	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-5AINC19B	10-15-04	1240	18.72	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-5AINC38	11-03-04	1630	37.88	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
Site identifier	Sample identifier	Collection			Neodymium	Praseodymium	Samarium	Terbium	Thorium	Thulium	Uranium	Ytterbium
		Date	Time	Duration (days)								
LR-5A	LR-5AINC0	09-26-04	2146	0.09	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
	LR-5AINC2	09-28-04	2210	2.11	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
	LR-5AINC4	09-30-04	0819	3.53	<.05	<.05	<.09	<.1	<1	<.045	.8	<.025
	LR-5AINC8	10-04-04	1745	7.93	<.05	<.05	<.09	<.1	<1	<.045	2.3	<.025
	LR-5AINC19B	10-15-04	1240	18.72	<.05	<.05	<.09	<.1	<1	<.045	3.6	<.025
	LR-5AINC38	11-03-04	1630	37.88	<.05	<.05	<.09	<.1	<1	<.045	2.7	<.025

**Table 29.** Concentrations of lanthanide and actinide elements in water from incubation experiments using sediment cores from Lake Roosevelt.—Continued

[All concentrations are in micrograms per liter. **Duration:** time since beginning of experiment; R, replicate. **Abbreviations:** com, contaminated. **Symbols:** <, less than]

Site identifier	Sample identifier	Collection			Cerium	Dyprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium
		Date	Time	Duration (days)								
LR-6	LR-6INC0	09-27-04	1910	0.11	<0.05	<0.04	<0.025	<0.025	<0.025	<0.025	<0.1	<0.5
	LR-6INC2	09-29-04	1730	2.04	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-6INC5	10-02-04	1340	4.88	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-6INC8	10-04-04	1530	6.96	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-6INC18A	10-15-04	1250	17.85	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-6INC18B	10-15-04	1251	R	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-6INC37	11-03-04	1640	37.01	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
Site identifier	Sample identifier	Collection			Neodymium	Praseodymium	Samarium	Terbium	Thorium	Thulium	Uranium	Yttrium
		Date	Time	Duration (days)								
LR-6	LR-6INC0	09-27-04	1910	0.11	<0.05	<0.05	<0.09	<0.1	<1	<0.045	<0.5	<0.025
	LR-6INC2	09-29-04	1730	2.04	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
	LR-6INC5	10-02-04	1340	4.88	<.05	<.05	<.09	<.1	<1	<.045	.6	<.025
	LR-6INC8	10-04-04	1530	6.96	<.05	<.05	<.09	<.1	<1	<.045	.6	<.025
	LR-6INC18A	10-15-04	1250	17.85	<.05	<.05	<.09	<.1	<1	<.045	1.6	<.025
	LR-6INC18B	10-15-04	1251	R	<.05	<.05	<.09	<.1	<1	<.045	1.7	<.025
	LR-6INC37	11-03-04	1640	37.01	<.05	<.05	<.09	<.1	<1	<.045	3.0	<.025
Site identifier	Sample identifier	Collection			Cerium	Dyprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium
		Date	Time	Duration (days)								
LR-7	LR-7AINC0	09-28-04	2130	0.08	<0.05	<0.04	<0.025	<0.025	<0.025	<0.025	<0.1	<0.5
	LR-7AINC2	09-30-04	0830	1.53	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-7AINC4	10-02-04	1345	3.75	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-7AINC8	10-06-04	0840	7.54	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-7AINC17A	10-15-04	1310	16.73	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-7AINC17B	10-15-04	1311	R	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-7AINC36	11-03-04	1650	35.88	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
Site identifier	Sample identifier	Collection			Neodymium	Praseodymium	Samarium	Terbium	Thorium	Thulium	Uranium	Yttrium
		Date	Time	Duration (days)								
LR-7	LR-7AINC0	09-28-04	2130	0.08	<0.05	<0.05	<0.09	<0.1	<1	<0.045	<0.5	<0.025
	LR-7AINC2	09-30-04	0830	1.53	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
	LR-7AINC4	10-02-04	1345	3.75	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
	LR-7AINC8	10-06-04	0840	7.54	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
	LR-7AINC17A	10-15-04	1310	16.73	<.05	<.05	<.09	<.1	<1	<.045	.6	<.025
	LR-7AINC17B	10-15-04	1311	R	<.05	<.05	<.09	<.1	<1	<.045	.6	<.025
	LR-7AINC36	11-03-04	1650	35.88	<.05	<.05	<.09	<.1	<1	<.045	.8	<.025

**Table 29.** Concentrations of lanthanide and actinide elements in water from incubation experiments using sediment cores from Lake Roosevelt.—Continued

[All concentrations are in micrograms per liter. **Duration:** time since beginning of experiment; R, replicate. **Abbreviations:** com, contaminated. **Symbols:** <, less than]

Site identifier	Sample identifier	Collection			Cerium	Dyprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium
		Date	Time	Duration (days)								
LR-7	LR-7RINC0	09-28-04	2150	0.07	0.06	<0.04	<0.025	<0.025	<0.025	<0.025	<0.1	<0.5
	LR-7RINC2	09-30-04	0835	1.52	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-7RINC4	10-02-04	1350	3.74	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-7RINC8	10-06-04	0850	7.53	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-7RINC17A	10-15-04	1315	16.71	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-7RINC17B	10-15-04	1316	R	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-7RINC36	11-03-04	1700	35.87	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
Site identifier	Sample identifier	Collection			Neodymium	Praseodymium	Samarium	Terbium	Thorium	Thulium	Uranium	Ytterbium
		Date	Time	Duration (days)								
LR-7	LR-7RINC0	09-28-04	2150	0.07	<0.05	<0.05	<0.09	<0.1	<1	<0.045	0.6	<0.025
	LR-7RINC2	09-30-04	0835	1.52	<.05	<.05	<.09	<.1	<1	<.045	.6	<.025
	LR-7RINC4	10-02-04	1350	3.74	<.05	<.05	<.09	<.1	<1	<.045	.7	<.025
	LR-7RINC8	10-06-04	0850	7.53	<.05	<.05	<.09	<.1	<1	<.045	.7	<.025
	LR-7RINC17A	10-15-04	1315	16.71	<.05	<.05	<.09	<.1	<1	<.045	1.1	<.025
	LR-7RINC17B	10-15-04	1316	R	<.05	<.05	<.09	<.1	<1	<.045	1.0	<.025
	LR-7RINC36	11-03-04	1700	35.87	<.05	<.05	<.09	<.1	<1	<.045	1.6	<.025
Site identifier	Sample identifier	Collection			Cerium	Dyprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium
		Date	Time	Duration (days)								
SA-8	SA-8INC0	09-22-04	2100	0.16	<0.05	<0.04	<0.025	<0.025	<0.025	<0.025	<0.1	<0.5
	SA-8INC2	09-24-04	1710	2.00	.10	<.04	<.025	.03	<.025	<.025	<.1	<.5
	SA-8INC4	09-26-04	1120	3.76	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	SA-8INC8	09-30-04	0815	7.63	.06	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	SA-8INC20A	10-12-04	1020	19.72	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	SA-8INC20B	10-12-04	1021	R	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	SA-8INC42	11-03-04	1710	42.00	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
Site identifier	Sample identifier	Collection			Neodymium	Praseodymium	Samarium	Terbium	Thorium	Thulium	Uranium	Ytterbium
		Date	Time	Duration (days)								
SA-8	SA-8INC0	09-22-04	2100	0.16	<0.05	<0.05	<0.09	<0.1	<1	<0.045	<0.5	<0.025
	SA-8INC2	09-24-04	1710	2.00	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
	SA-8INC4	09-26-04	1120	3.76	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
	SA-8INC8	09-30-04	0815	7.63	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
	SA-8INC20A	10-12-04	1020	19.72	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
	SA-8INC20B	10-12-04	1021	R	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
	SA-8INC42	11-03-04	1710	42.00	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025

**Table 30.** Depth interval, weights of wet sediment, slurry, dry sediment, porewaters, and reservoir water during tumbling experiment.

[All weights are in grams. Weight of porewater at beginning of experiment = Original wet sediment weight – Dry weight at end of experiment. Weight of overlying water added = Slurry weight – Original wet sediment weight. **Abbreviations:** cm, centimeter]

Site identifier	Sample identifier	Depth interval (cm)	Weights (grams)				
			Original wet sediment	Slurry	Dry sediment at end of experiment	Porewater at beginning of experiment	Reservoir water added
LR-2	LR-2	0–2	96.1	128.6	17.9	78.3	32.4
LR-3	LR-3	0–2	106.4	139	27.9	78.5	32.6
LR-4A	LR-4A	0–2	93.7	123.2	22.9	70.8	29.5
LR-5A	LR-5A	0–2	101	134	40.1	60.9	33
		4.7–6.2	78.2	102.1	58.9	19.3	23.9
LR-6	LR-6	0–2	133.4	171.6	79.0	54.4	38.2
		4.2–5.2	88.2	119.6	62.6	25.6	31.4
LR-7	LR-7	0–2	212.6	242.5	175.2	37.4	29.9
	LR-7R (replicate)	0–2	143.7	179	111.3	32.4	35.3
SA-8	SA-8	0–2	114.6	146.2	44.4	70.2	31.6
RM 743	<sup>1</sup> RM 743	Surface	147.7	221.2	147.5	.2	73.5
	<sup>1</sup> RM 743 replicate	Surface	154.4	240.9	154.3	.1	86.5

<sup>1</sup>RM 743 is a sample of unsorted beach sand containing slag that was collected from river mile 743 of the Columbia River on September 13, 2002, and analyzed as part of a previous study (Cox and others, 2005).

**Table 31.** Concentrations of alkali and alkaline elements and non-metals in supernatants from tumbling experiments using sediment cores and river sediment with slag from Lake Roosevelt.

[Concentrations are in micrograms per liter unless otherwise indicated. **Sampling time** is elapsed time after mixing slurry. **Abbreviations:** cm, centimeter; min., minute; mg/L, milligram per liter. **Symbols:** <, less than]

Site identifier	Sample identifier	Depth interval (cm)	Sampling time	Alkali and alkaline earth elements									
				Barium	Beryllium	Calcium (mg/L)	Cesium	Lithium	Magnesium (mg/L)	Potassium (mg/L)	Rubidium	Sodium (mg/L)	Strontium
LR-2	LR-2	0–2	15 min.	66.4	<0.05	17.4	0.04	<4.5	4.4	1.37	2.71	2.08	106
			43 days	305	<.05	65.8	.14	<4.5	15.3	2.66	5.98	2.94	392
LR-3	LR-3	0–2	15 min.	91.4	<.05	24.9	.06	<4.5	6.1	1.21	3.78	1.81	139
			43 days	344	<.05	75.9	.13	<4.5	18.1	2.11	7.69	2.60	433
LR-4A	LR-4A	0–2	15 min.	75.6	<.05	16	.10	<4.5	3.8	1.52	3.12	2.34	90
			43 days	256	<.05	68.4	.19	5.3	15.4	2.63	6.21	3.31	377
LR-5A	LR-5A	0–2	15 min.	87.7	<.05	21.1	.13	<4.5	4.1	1.66	3.03	2.46	107
			43 days	237	<.05	137	.25	<4.5	24.3	4.42	5.9	4.78	661
		4.7–6.2	15 min.	159	<.05	29.9	.14	7.8	5.9	2.03	4.08	2.83	136
			43 days	404	<.05	97.4	.19	29.8	21.6	4.22	7.98	6.54	366
LR-6	LR-6	0–2	15 min.	128	<.05	25.9	.03	<4.5	4.0	2.10	3.12	2.63	131
			43 days	525	<.05	146	.17	4.6	22.8	6.05	7	6.34	732
		4.2–5.2	15 min.	160	<.05	29	.04	<4.5	4.3	3.06	4.44	2.76	156
			43 days	639	<.05	113	.11	17.8	21.4	7.18	10.2	6.36	586
LR-7	LR-7	0–2	15 min.	60.3	<.05	27.9	<.02	4.6	6.3	.88	1.47	2.24	145
			43 days	128	<.05	64	<.02	6.2	19.0	2.30	2.22	3.16	327
	LR-7R	0–2	15 min.	47.7	<.05	28.8	<.02	<4.5	5.5	1.35	1.57	2.47	123
			43 days	152	<.05	73.7	.03	34.6	35.4	5.80	4.89	5.45	294
SA-8	SA-8	0–2	15 min.	34.8	<.05	13.8	<.02	<4.5	3.4	1.16	1.28	2.11	79
			43 days	122	<.05	68.2	.03	<4.5	16.0	2.52	2.85	4.24	368
RM 743	RM 743	Surface	15 min.	47.2	<.05	25.2	<.02	<4.5	5.1	1.02	.74	2.31	87
			43 days	68.8	<.05	36.3	<.02	5.7	11.9	2.09	2.51	2.63	144
	RM 743 -replicate	Surface	15 min.	44.4	<.05	23.8	<.02	<4.5	5.0	.99	.78	2.28	85
			43 days	71.8	<.05	31.9	.04	20.5	16.8	4.70	6.64	3.56	123

**Table 31.** Concentrations of alkali and alkaline elements and non-metals in supernatants from tumbling experiments using sediment cores and river sediment with slag from Lake Roosevelt.—Continued

[Concentrations are in micrograms per liter unless otherwise indicated. **Sampling time** is elapsed time after mixing slurry. **Abbreviations:** cm, centimeter; min., minute; mg/L, milligram per liter. **Symbols:** <, less than]

Site identifier	Sample identifier	Depth (cm)	Sampling time	Non-Metals				
				Arsenic (µg/L)	Phosphorus (mg/L)	Selenium (µg/L)	Silica (mg/L)	Sulfate (mg/L)
LR-2	LR-2	0–2	15 min.	2	<0.05	<5	18	<10
			43 days	3	.09	<5	40	17
LR-3	LR-3	0–2	15 min.	<1	.06	<5	31	<10
			43 days	4	.10	<5	47	<10
LR-4A	LR-4A	0–2	15 min.	2	<.05	<5	30	<10
			43 days	5	.08	<5	44	32
LR-5A	LR-5A	0–2	15 min.	2	<.05	<5	12	<10
			43 days	2	<.05	<5	26	<10
		4.7–6.2	15 min.	<1	<.05	<5	12	<10
			43 days	2	<.05	<5	23	74
LR-6	LR-6	0–2	15 min.	2	<.05	<5	7.9	<10
			43 days	5	<.05	<5	28	<10
		4.2–5.2	15 min.	2	<.05	<5	7.0	<10
			43 days	3	.10	<5	18	114
LR-7	LR-7R	0–2	15 min.	2	<.05	<5	6	12
			43 days	2	<.05	<5	13	40
	LR-7R	0–2	15 min.	2	<.05	<5	7.2	15
			43 days	2	.08	<5	15	42
SA-8	SA-8	0–2	15 min.	<1	<.05	<5	10	<10
			43 days	3	.07	<5	36	17
RM 743	<sup>1</sup> RM 743	Surface	15 min.	2	.06	<5	4.4	38
			43 days	4	<.05	<5	10	50
	<sup>1</sup> RM 743 -replicate	Surface	15 min.	2	<.05	<5	4.2	22
			43 days	5	.08	<5	8.9	53

<sup>1</sup>RM 743 is a sample of unsorted beach sand containing slag that was collected from river mile 743 of the Columbia River on September 13, 2002, and analyzed as part of a previous study (Cox and others, 2005).

**Table 32.** Concentrations of metals in supernatants from tumbling experiments using sediment cores and river sediment with slag from Lake Roosevelt.[All concentrations are in micrograms per liter. **Sampling time** after mixing slurry. **Abbreviations:** cm, centimeter; min., minute. **Symbols:** <, less than]

Site identifier	Sample identifier	Depth interval (cm)	Sampling time	Metals													
				Aluminum	Antimony	Bismuth	Cadmium	Chromium	Cobalt	Copper	Gallium	Germanium	Iron	Lead	Manganese	Molybdenum	Nickel
LR-2	LR-2	0–2	15 min.	52.9	0.6	<0.2	<.1	<5	0.60	0.7	0.20	<0.025	<250	1.0	5,720	3.1	1.7
			43 days	18.6	<.3	<.2	.11	<5	1.68	1.0	.73	<.025	<250	.9	43,000	17.9	2.7
LR-3	LR-3	0–2	15 min.	62.2	1.2	<.2	.26	<5	.77	2.4	.20	<.025	<250	2.5	9,740	10.2	1.6
			43 days	28.8	<.3	<.2	.68	<5	2.46	3.1	.70	<.025	<250	5.9	50,600	26.0	4.0
LR-4A	LR-4A	0–2	15 min.	146	.5	<.2	.19	<5	.73	2.7	.09	<.025	<250	2.2	2,460	<2	1.1
			43 days	35.1	<.3	<.2	<.1	<5	3.08	.8	.20	<.025	9,960	.7	11,800	3.3	2.6
LR-5A	LR-5A	0–2	15 min.	37	2.0	<.2	<.1	<5	.51	<.5	<.05	<.025	273	2.2	591	<2	.6
			43 days	19.8	.8	<.2	<.1	<5	1.46	.9	.10	<.025	1,230	.7	5,240	18.0	.6
		4.7–6.2	15 min.	25.1	6.7	<.2	<.1	<5	1.02	.6	<.05	.53	593	1.6	923	6.1	.6
			43 days	14.3	2.5	<.2	<.1	<5	2.07	<.5	.09	.66	<250	<.25	3,590	13.9	.9
LR-6	LR-6	0–2	15 min.	42.4	12.0	<.2	<.1	<5	.18	2.4	<.05	.3	<250	3.6	183	5.2	.7
			43 days	19.5	1.0	<.2	<.1	<5	1.72	.6	<.05	.56	3,750	1.6	3,500	34.5	<.4
		4.2–5.2	15 min.	48.4	60.4	<.2	.13	<5	<.1	5.1	.22	.46	<250	7.3	46.2	9.7	<.4
			43 days	20.7	7.8	<.2	.12	<5	.27	3.5	.07	.7	<250	4.2	416	27.1	.8
LR-7	LR-7	0–2	15 min.	85.2	27.4	<.2	.20	<5	.18	26.8	.20	.26	491	16.2	10.9	<2	<.4
			43 days	29	160	<.2	.19	<5	<.1	30.0	.07	.38	<250	1.6	7.3	4.1	<.4
	LR-7R	0–2	15 min.	70.8	17.7	<.2	<.1	<5	<.1	21.0	.07	.28	358	7.5	7.5	2.6	<.4
			43 days	256	155	<.2	.34	<5	.36	94.2	.24	.68	914	18.7	38.5	6.0	1.6
SA-8	SA-8	0–2	15 min.	90.3	.8	<.2	<.1	<5	.48	<.5	<.05	<.025	<250	.3	530	<2	.5
			43 days	27.8	.5	<.2	<.1	<5	1.23	<.5	.10	<.025	740	<.25	3,370	<2	1.2
RM 743	<sup>1</sup> RM 743		15 min.	68.4	22.5	<.2	.32	<5	.32	51.8	.10	<.025	338	7.9	19	3.6	.8
			43 days	40.6	336	<.2	.13	<5	.47	55.8	<.05	.53	<250	4.5	117	36.0	1.2
	<sup>1</sup> RM 743-replicate		15 min.	58.7	21.2	<.2	.21	<5	.23	50.6	.07	<.0	259	7.0	18.1	3.3	1.1
			43 days	160	498	<.2	.31	<5	.68	140.0	.07	.7	773	17.4	148	54.6	2.0

**Table 32.** Concentrations of metals in supernatants from tumbling experiments using sediment cores and river sediment with slag from Lake Roosevelt.—Continued[All concentrations are in micrograms per liter. **Sampling time** after mixing slurry. **Abbreviations:** cm, centimeter; min., minute. **Symbols:** <, less than]

Site identifier	Sample identifier	Depth (cm)	Sampling time	Metals										Zinc	Zirconium
				Niobium	Scandium	Silver	Tantalum	Thallium	Titanium	Tungsten	Vanadium	Yttrium			
LR-2	LR-2	0–2	15 min.	<1	<3	<15	<0.1	<0.2	<2.5	<0.5	<2.5	0.09	6.8	<1	
			43 days	<1	6.3	<15	<.1	<.2	<2.5	.89	<2.5	.22	12.7	<1	
LR-3	LR-3	0–2	15 min.	<1	4.8	<15	<.1	<.2	<2.5	<.5	<2.5	.21	5.3	<1	
			43 days	<1	7.6	<15	<.1	.3	<2.5	<.5	2.6	.42	14.0	<1	
LR-4A	LR-4A	0–2	15 min.	<1	4.5	<15	<.1	<.2	<2.5	<.5	<2.5	.17	8.6	<1	
			43 days	<1	6.8	<15	<.1	<.2	<2.5	<.5	<2.5	.08	12.4	<1	
LR-5A	LR-5A	0–2	15 min.	<1	<3	<15	<.1	<.2	<2.5	<.5	<2.5	.10	10.4	<1	
			43 days	<1	3.6	<15	<.1	<.2	<2.5	.95	<2.5	.09	11.2	<1	
		4.7–6.2	15 min.	<1	<3	<15	<.1	<.2	<2.5	<.5	<2.5	<.05	21.4	<1	
			43 days	<1	3.3	<15	<.1	<.2	<2.5	<.5	<2.5	<.05	44.8	<1	
LR-6	LR-6	0–2	15 min.	<1	<3	<15	<.1	<.2	<2.5	.93	<2.5	<.05	7.5	<1	
			43 days	<1	3.1	<15	<.1	<.2	<2.5	1.64	<2.5	.11	5.4	<1	
		4.2–5.2	15 min.	<1	<3	<15	<.1	<.2	<2.5	2.08	<2.5	.06	16.0	<1	
			43 days	<1	<3	<15	<.1	<.2	2.6	1.99	<2.5	.15	13.1	<1	
LR-7	LR-7	0–2	15 min.	<1	<3	<15	<.1	<.2	7.2	<.5	<2.5	.21	74.1	<1	
			43 days	<1	<3	<15	<.1	<.2	<2.5	<.5	<2.5	.10	60.2	<1	
	LR-7R	0–2	15 min.	<1	<3	<15	<.1	<.2	7.0	<.5	<2.5	.14	30.6	<1	
			43 days	<1	<3	<15	<.1	<.2	12.7	<.5	<2.5	.55	176	<1	
SA-8	SA-8	0–2	15 min.	<1	<3	<15	<.1	<.2	<2.5	<.5	<2.5	.06	3.0	<1	
			43 days	<1	4.7	<15	<.1	<.2	<2.5	<.5	<2.5	.10	2.9	<1	
RM 743	<sup>1</sup> RM 743		15 min.	<1	<3	<15	<.1	<.2	<2.5	<.5	<2.5	.18	65.4	<1	
			43 days	<1	<3	<15	<.1	<.2	<2.5	.98	<2.5	.07	45.4	<1	
	<sup>1</sup> RM 743-replicate		15 min.	<1	<3	<15	<.1	<.2	<2.5	<.5	<2.5	.10	60.9	<1	
			43 days	<1	<3	<15	<.1	<.2	7.5	2.5	<2.5	.28	118	<1	

<sup>1</sup>RM 743 is a sample of unsorted beach sand containing slag that was collected from river mile 743 of the Columbia River on September 13, 2002 and analyzed as part of a previous study (Cox and others, 2005).

**Table 33.** Concentrations of lanthanide and actinide elements in supernatants from tumbling experiments using sediment cores and river sediment with slag from Lake Roosevelt.

[All concentrations are in micrograms per liter. **Sampling time** is elapsed time after mixing slurry. **Abbreviations:** cm, centimeter; min., minute. **Symbols:** <, less than]

Site identifier	Sample identifier	Depth (cm)	Sampling time	Cerium	Dyprosium	Erbium	Europium	Gadolinium	Holmium	Lanthanum	Lutetium
LR-2	LR-2	0–2	15 min.	0.14	<0.04	<0.025	<0.025	<0.025	<0.025	<0.1	<0.5
			43 days	.12	<.04	<.025	.04	<.025	<.025	<.1	<.5
LR-3	LR-3	0–2	15 min.	.24	<.04	<.025	<.025	.04	<.025	.18	<.5
			43 days	.17	<.04	.03	.07	.04	<.025	.13	<.5
LR-4A	LR-4A	0–2	15 min.	.36	.05	<.025	<.025	<.025	<.025	.24	<.5
			43 days	.08	<.04	<.025	.03	<.025	<.025	<.1	<.5
LR-5A	LR-5A	0–2	15 min.	.12	<.04	<.025	<.025	<.025	<.025	.11	<.5
			43 days	.07	<.04	<.025	.04	<.025	<.025	<.1	<.5
		4.7–6.2	15 min.	.11	<.04	<.025	<.025	<.025	<.025	<.1	<.5
			43 days	<.05	<.04	<.025	.03	<.025	<.025	<.1	<.5
LR-6	LR-6	0–2	15 min.	.07	<.04	<.025	<.025	<.025	<.025	<.1	<.5
			43 days	.07	<.04	<.025	.09	<.025	<.025	<.1	<.5
		4.2–5.2	15 min.	.11	<.04	<.025	<.025	.03	<.025	<.1	<.5
			43 days	.11	<.04	.03	.12	.03	<.025	.12	<.5
LR-7	LR-7	0–2	15 min.	.26	<.04	<.025	<.025	.04	<.025	.24	<.5
			43 days	<.05	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	LR-7R	0–2	15 min.	.20	<.04	<.025	<.025	<.025	<.025	.19	<.5
			43 days	.51	<.04	<.025	.03	.05	<.025	.55	<.5
SA-8	SA-8	0–2	15 min.	.14	<.04	<.025	<.025	.03	<.025	<.1	<.5
			43 days	.16	<.04	<.025	<.025	<.025	<.025	<.1	<.5
RM 743	RM 743	Surface	15 min.	.14	<.04	<.025	<.025	.03	<.025	.15	<.5
			43 days	.06	<.04	<.025	<.025	<.025	<.025	<.1	<.5
	RM 743-replicate	Surface	15 min.	.11	<.04	<.025	<.025	<.025	<.025	<.1	<.5
			43 days	.25	<.04	<.025	<.025	.04	<.025	.31	<.5

**Table 33.** Concentrations of lanthanide and actinide elements in supernatants from tumbling experiments using sediment cores and river sediment with slag from Lake Roosevelt.—Continued

[All concentrations are in microgram per liter. **Sampling time** is elapsed time after mixing slurry. **Abbreviations:** cm, centimeter; min., minute. **Symbols:** <, less than]

Site identifier	Sample identifier	Depth interval (cm)	Sampling time	Neodymium	Praseodymium	Samarium	Terbium	Thorium	Thulium	Uranium	Ytterbium
LR-2	LR-2	0–2	15 min.	<0.05	<0.05	<0.09	<0.1	<1	<0.045	<0.5	0.03
			43 days	.09	<.05	<.09	<.1	<1	<.045	43.6	.04
LR-3	LR-3	0–2	15 min.	.10	<.05	<.09	<.1	<1	<.045	<.5	.04
			43 days	.11	<.05	<.09	<.1	<1	<.045	53.6	.04
LR-4A	LR-4A	0–2	15 min.	.17	<.05	<.09	<.1	<1	<.045	<.5	<.025
			43 days	<.05	<.05	<.09	<.1	<1	<.045	9.9	<.025
LR-5A	LR-5A	0–2	15 min.	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
			43 days	.08	<.05	<.09	<.1	<1	<.045	2.0	<.025
		4.7–6.2	15 min.	.09	<.05	<.09	<.1	<1	<.045	1.2	<.025
			43 days	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
LR-6	LR-6	0–2	15 min.	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
			43 days	.12	<.05	<.09	<.1	<1	<.045	21.8	<.025
		4.2–5.2	15 min.	.10	<.05	<.09	<.1	<1	<.045	6.8	<.025
			43 days	.10	<.05	<.09	<.1	<1	<.045	30.2	<.025
LR-7	LR-7	0–2	15 min.	.12	<.05	<.09	<.1	<1	<.045	.81	<.025
			43 days	<.05	<.05	<.09	<.1	<1	<.045	6.9	<.025
	LR-7R	0–2	15 min.	.09	<.05	<.09	<.1	<1	<.045	<.5	<.025
			43 days	.42	.10	<.09	<.1	<1	<.045	21.8	.04
SA-8	SA-8	0–2	15 min.	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
			43 days	<.05	<.05	<.09	<.1	<1	<.045	8.13	<.025
RM 743	<sup>1</sup> RM 743	Surface	15 min.	.10	<.05	<.09	<.1	<1	<.045	<.5	<.025
			43 days	<.05	<.05	<.09	<.1	<1	<.045	<.5	<.025
	<sup>1</sup> RM 743-replicate	Surface	15 min.	.08	<.05	<.09	<.1	<1	<.045	<.5	.03
			43 days	.18	<.05	<.09	<.1	<1	<.045	<.5	<.025

<sup>1</sup>RM 743 is a sample of unsorted beach sand containing slag that was collected from river mile 743 of the Columbia River on September 13, 2002 and analyzed as part of a previous study (Cox and others, 2005).

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Paulson and others

**Concentrations of Elements in Sediments and Selective Fractions of  
Sediments, and in Natural Waters in Contact with Sediments  
From Lake Roosevelt, Washington, September 2004**

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