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

Prepared in cooperation with
Douglas County and
U.S. Forest Service

Major-Ion, Nutrient, and Trace-Element Concentrations in the Steamboat Creek Basin, Oregon, 1996

Water-Resources Investigations Report 98–4105

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By Frank A. Rinella

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Portland, Oregon: 1998

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CONVERSION FACTORS

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in)
millimeter (mm)	0.03937	inch
meter (m)	3.281	foot (ft)
	Volume	
milliliter (mL)	0.001057	quart (qt)
liter (L)	1.057	quart
	Flow (Volume per unit time)	
cubic feet per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
	Concentration in Water	
milligrams per liter (mg/L)	1	part per million (ppm)
micrograms per liter (µg/L)	1	parts per billion (ppb)
	Concentration in Bottom Sediment	
percent	1	parts per hundred
microgram per gram (µg/g)	1	parts per million
	Temperature	
degrees Celsius (°C)	°F = 1.8 (°C) + 32	degrees Fahrenheit (°F)

Major-Ion, Nutrient, and Trace-Element Concentrations in the Steamboat Creek Basin, Oregon, 1996

By Frank A. Rinella

Abstract

In September 1996, a water-quality study was done by the U.S. Geological Survey, in coordination with the U.S. Forest Service, in headwater streams of Steamboat Creek, a tributary to the North Umpqua River Basin in southwestern Oregon. Field measurements were made in and surface-water and bottom-sediment samples were collected from three tributaries of Steamboat Creek—Singe Creek, City Creek, and Horse Heaven Creek—and at one site in Steamboat Creek upstream from where the three tributaries flow into Steamboat Creek.

Water samples collected in Singe Creek had larger concentrations of most major-ion constituents and smaller concentrations of most nutrient constituents than was observed in the other three creeks. City Creek, Horse Heaven Creek, and Steamboat Creek had primarily calcium bicarbonate water, whereas Singe Creek had primarily a calcium sulfate water; the calcium sulfate water detected in Singe Creek, along with the smallest observed alkalinity and pH values, suggests that Singe Creek may be receiving naturally occurring acidic water.

Of the 18 trace elements analyzed in filtered water samples, only 6 were detected—aluminum, barium, cobalt, iron, manganese, and zinc. All six of the trace elements were detected in Singe Creek, at concentrations generally larger than those observed in the other three creeks. Of the detected trace elements, only iron and zinc have chronic toxicity criteria established by the U.S. Environmental Protection Agency (USEPA) for the protection of aquatic life; none exceeded the USEPA criterion.

Bottom-sediment concentrations of antimony, arsenic, cadmium, copper, lead, mercury, zinc, and organic carbon were largest in City Creek. In City Creek and Horse Heaven Creek, concentrations for 11 constituents—antimony, arsenic, cadmium, copper, lead, manganese (Horse Heaven Creek only), mercury, selenium, silver, zinc, and organic carbon (City Creek only)—exceeded concentrations considered to be enriched in streams of the nearby Willamette River Basin, whereas in Steamboat Creek only two trace elements—antimony and nickel—exceeded Willamette River enriched concentrations. Bottom-sediment concentrations for six of these constituents in City Creek and Horse Heaven Creek—arsenic, cadmium, copper, lead, mercury, and zinc—also exceeded interim Canadian threshold effect level (TEL) concentrations established for the protection of aquatic life, whereas only four constituents between Singe Creek and Steamboat Creek—arsenic, chromium, copper (Singe Creek only), and nickel—exceeded the TEL concentrations.

INTRODUCTION

The approximately 6,000 acre Bohemia Mining District, which straddles the divide between the Steamboat Creek Subbasin (fig. 1) of the North Umpqua River Basin and the Willamette River Basin to the northwest, was formed in 1867. Since then, hardrock mining, primarily for gold, has been conducted within the watersheds of several small tributaries of Steamboat Creek; these tributaries include City Creek and Horse Heaven Creek (Tim LaMarr, U.S. Forest Service, written commun., 1998). To date, no sampling has been done to characterize major-ion, nutrient, and trace-element concentrations in Steamboat Creek or any of its tributaries.

In 1996, the U.S. Geological Survey (USGS), in cooperation with Douglas County, Oregon, and with the U.S. Forest Service, began a study of the quality of water and bottom sediment in four headwater streams of Steamboat Creek, a tributary to the North Umpqua

River Basin in southwestern Oregon. The headwaters of two of the tributaries drain the Bohemia Mining District (City Creek and Horse Heaven Creek) and two tributaries are outside of mining activities (Singe Creek and Steamboat Creek).

Purpose and Scope

This report presents the concentrations of major ions, nutrients, and trace elements in water and bottom sediments collected in the four tributaries during the low-flow conditions of September 9–13, 1996. Stream-water chemistry results are contrasted, and trace-element concentrations compared with U.S. Environmental Protection Agency chronic aquatic life toxicity criteria (U.S. Environmental Protection Agency, 1986). Bottom-sediment trace-element results also are contrasted and compared with concentrations considered to be enriched in streams of the nearby Willamette River Basin and to interim Canadian threshold effect level (TEL) concentrations established for the protection of aquatic life (Environment Canada, 1995).

Acknowledgments

The author wishes to express special thanks to Mikeal Jones, Steve Hofford, and Larry Broeker from the Supervisor's Office of the Umpqua National Forest, U.S. Forest Service, and to Tim LaMarr from the North Umpqua Ranger District for their assistance and funding of this monitoring effort. Within the U.S. Geological Survey, special thanks also to Mary Janet, who prepared and organized the necessary supplies and equipment for the field effort, and to Chris Brugato, who contributed valuable field assistance.

SAMPLE COLLECTION AND ANALYSIS

Field measurements and surface-water and bottom-sediment samples at each of the four sites (fig. 1 and table 1) included streamflow, stream temperature, specific conductance, dissolved oxygen, pH, alkalinity, major ions in filtered water (8 constituents), low-level concentrations of nutrients in filtered and unfiltered water (8 constituents), low-level concentrations of trace elements in filtered water (18 elements), and trace elements and carbon in bottom sediment (47 elements). A list of the chemical constituents analyzed and their minimum reporting levels (MRLs) are given in Appendix A. The MRL is the smallest measured concentration of a constituent that may be reliably reported given the analytical method (Timme, 1995).

Water

Stream temperature, specific conductance, dissolved oxygen, and pH were measured using a calibrated Hydrolab multiparameter unit. Because stream widths were less than 8 feet, field measurements were made only near the center of flow at 1 foot or less below water surface. The Hydrolab unit was calibrated at each site before and after sampling. Stream temperatures were recorded to the nearest 0.1°C (degree Celsius); specific conductance to the nearest 1 µS/cm (microsiemen per centimeter) at 25°C; dissolved oxygen to the nearest 0.1 mg/L (milligram per liter); and pH to the nearest 0.1 pH units. Measurements of streamflow were made in accordance with standard USGS procedures (Rantz and others, 1982). Alkalinity measurements were made on filtered water samples using an incremental titration method (Shelton, 1994), and results were reported to the nearest 1 mg/L as calcium carbonate ($CaCO_3$).

Water samples were collected using 1-liter narrow-mouth acid-rinsed polyethylene bottles from a minimum of eight verticals in the cross section, using an equal-width-increment method described by Edwards and Glysson (1988), and composited into a 8-liter polyethylene acid-rinsed churn splitter. Sample and compositing containers were prerinsed with native water prior to sample collection. Water samples were collected using clean procedures as outlined by Horowitz and others (1994). Samples were chilled on ice from time of sample collection until analysis, except when samples were processed. Processing of the field samples was accomplished either in the mobile field laboratory or in an area suitably clean for carrying out the filtering and preservation procedures.

Samples for major ions, nutrients, and trace elements in filtered water (operationally defined as dissolved) were passed through 0.45 µm (micrometer) pore-size capsule filters into polyethylene bottles using procedures outlined by Horowitz and others (1994). Filtered-water trace-element samples were preserved with 0.5 mL (milliliter) of ultra-pure nitric acid per 250 mL of sample; nutrient samples were placed in dark brown polyethylene bottles and were chilled for preservation. All chemical samples were

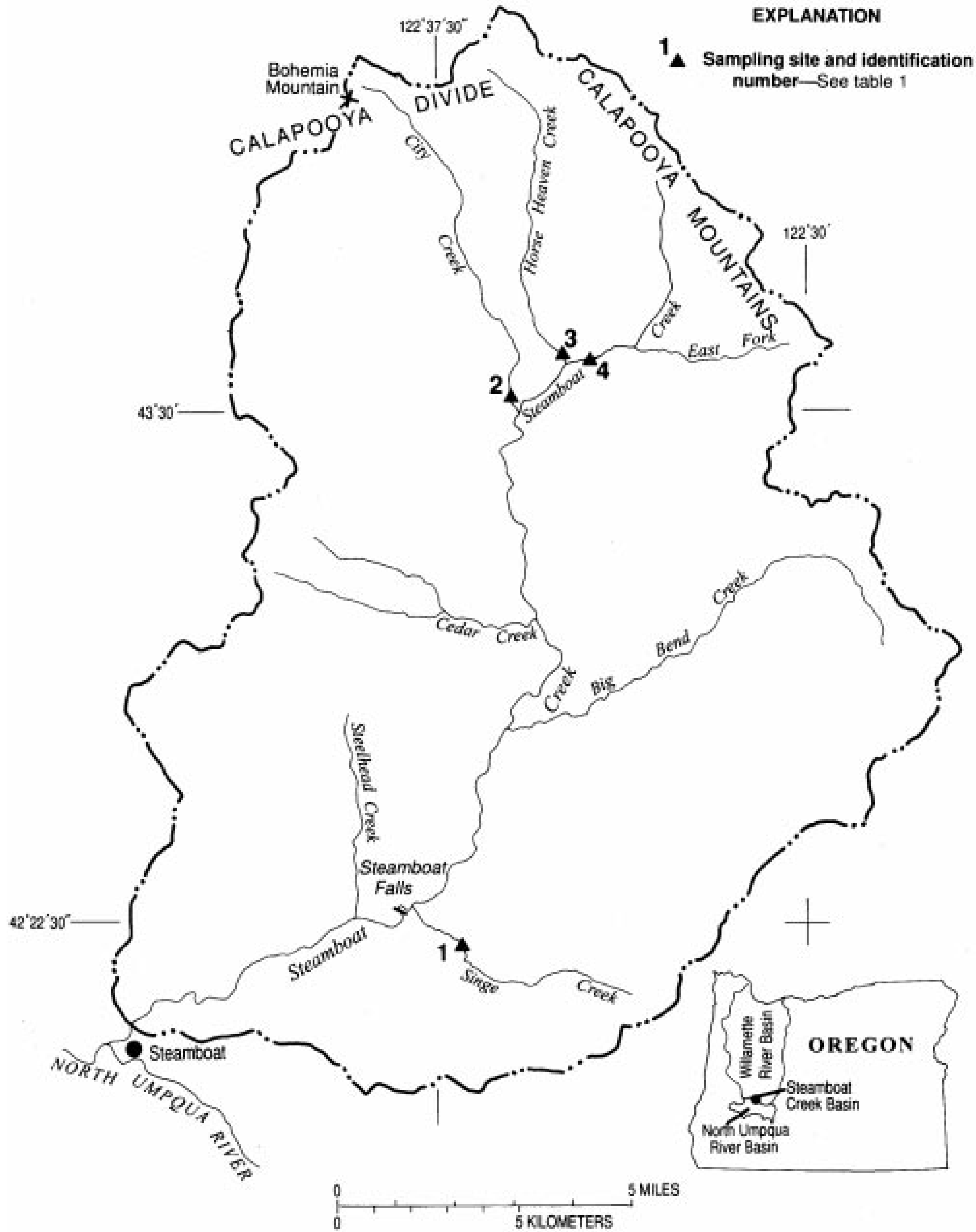

Figure 1. Sampling sites in the Steamboat Creek Basin, Oregon, September 1996.

Table 1. Sampling sites in the Steamboat Creek Basin, Oregon, September 1996

[Site locations are shown in figure 1]

Site index number	Site name	Site location Latitude / Longitude
1	Singe Creek near Steamboat	43°22’13” / 122°37’00”
2	City Creek near Steamboat	43°30’03” / 122°35’49”
3	Horse Heaven Creek near Steamboat	43°30’44” / 122°34’53”
4	Steamboat Creek near Steamboat	43°30’42” / 122°34’48”

shipped to the USGS National Water Quality Laboratory (NWQL) in Arvada, Colorado, for analysis according to methods outlined by Fishman (1993).

Bottom Sediment

Bottom-sediment samples were collected with a Teflon scoop and composited into 2-quart Pyrex containers from a minimum of 10 depositional areas at each site, using cleaning and sampling procedures outlined by Shelton and Capel (1994); two 2-quart Pyrex containers were filled with bottom sediment at each site. Only the surficial 2–3 cm (centimeter) of sediment was collected from each depositional area to ensure that only the most recently deposited materials would be sampled. The bottom-sediment samples were chilled until they were processed. The contents of the two 2-quart Pyrex containers were transferred to a 4-quart Pyrex container and then homogenized. Subsamples for trace-element analysis were processed by wet sieving (using native water) through a 62-µm nylon mesh cloth, and contents were placed into acid-rinsed 500 mL, wide-mouth, polyethylene containers. After most of the sieved sediments had settled, the supernatant (native water) was decanted from the < (less than) 62 µm sediment fraction before being shipped to NWQL. Trace-element analysis were performed by the USGS Analytical Chemistry Services Group according to procedures established for evaluating the chemical composition of geologic materials (Arbogast, 1990).

Quality Assurance

To ensure the accuracy and precision of the analysis of the water and bottom-sediment samples, approximately 20 percent of the samples were collected and analyzed for the purpose of quality control (Appendix B). The following types of quality-control samples were collected.

(1) Trace-element field blank samples. This type of sample required passing a volume of trace-element-free water through the same sampling, processing, and preservation method used for the native-water samples. The trace-element field blank sample was analyzed using an analytical method that provided lower MRLs than the native-water samples to check for low-level trace-element contamination (Appendix A, table A–1). Results of this work showed no contamination, with the possible exception of some slight enrichment of calcium, silica, and zinc (Appendix B, table B–1). Concentrations of calcium, silica, and zinc observed in the field blank were below their MRLs used in the native-water samples, and therefore no corrections to the native-water results were necessary.

(2) Major-ion, nutrient, and trace-element field split samples. The volume of native water collected at Horse Heaven Creek was divided (split) into two samples and analyzed individually. Results of this work showed excellent agreement between the split-sample results, indicating a high degree of processing and laboratory precision (Appendix B, table B–2, and Appendix C table C–1 and table C–2). A bottom-sediment trace-element sample from Horse Heaven Creek also was split; however, insufficient fine material (<62 µm) was available for the second sample. In its place, a sample sieved at <2 mm (millimeter) was analyzed and results were compared to those from the <62 µm fraction. Results of the bottom-sediment comparison showed that of the 13 trace elements commonly referred to in the literature, cadmium, copper, mercury, selenium, silver, and zinc were observed at concentrations from 1.5 to 4 times larger in the <62 µm fraction than in the <2 mm fraction, whereas antimony, arsenic, chromium, cobalt, lead, manganese, and nickel were observed at about the same concentrations in both fractions; organic-carbon content was more than 12.5 times larger in the <62 µm sediment fraction (Appendix C table C–3) than in the <2 mm sediment fraction (Appendix B, table B–3).

A comparison was made between the balance of anions and cations in each filtered sample to check on the accuracy of the combined major-ion concentrations. Anion and cation microequivalent differences ranged from -1.2 to 2.2 percent, and were considered excellent for the low-buffered water in the Steamboat Creek Basin.

RESULTS

Water Chemistry

Streamflow and field water-quality measurements were collected at the four sites in the Steamboat Creek Basin as given in Appendix C, table C–1. Streamflows in September 1996 were low, ranging from 0.71 ft^3/s (cubic feet per second) at City Creek to 1.81 ft^3/s at Singe Creek. Although streamflows were low, water temperatures remained moderately low, ranging from 12.1°C at Singe Creek to 15.0°C at City Creek. Dissolved-oxygen concentrations were close to saturation, ranging from 95 percent of saturation at Singe Creek to 99 percent of saturation at City Creek. Singe Creek had the largest specific conductance value (154 µS/cm) and the smallest pH (7.3 pH units), whereas City Creek had the smallest specific conductance value (43 µS/cm) and Steamboat Creek had the largest pH (8.1 pH units). Anion and cation balances for the four sites were plotted on a trilinear diagram (fig. 2) to graphically represent the relative proportion of the ions. City Creek, Steamboat Creek, and Horse Heaven Creek had primarily calcium bicarbonate waters, with calcium contributing between 57 to 59 percent of the cation concentrations and bicarbonate contributing between 83 and 93 percent of the anion concentrations. Singe Creek had primarily a calcium sulfate water, with 61 percent calcium and 94 percent sulfate contributions; the bicarbonate ion in Singe Creek contributed only 3.8 percent of the anion concentration. The increased sulfate concentration and low alkalinity (3 mg/L as $CaCO_3$) suggests that Singe Creek is probably receiving naturally occurring acidic waters. Of the four sites, Singe Creek had the largest total dissolved-solids concentration, and the largest major-ion concentrations for calcium, magnesium, potassium, silica, and sulfate, whereas Steamboat Creek had the largest sodium, bicarbonate, and chloride concentrations.

Nitrogen and phosphorus concentrations generally were low. All whole-water (unfiltered) concentrations of ammonia plus organic nitrogen were below their MRLs (<0.2 mg/L), whereas filtered-water nitrite plus nitrate concentrations ranged from <0.005 mg/L in Singe Creek and Steamboat Creek to 0.032 mg/L in Horse Heaven Creek. Whole-water concentrations of phosphorus ranged from 0.002 mg/L in Singe Creek to 0.036 mg/L in Steamboat Creek, whereas soluble reactive (ortho) phosphorus concentrations ranged from <0.001 mg/L in Singe Creek and City Creek to 0.021 mg/L in Steamboat Creek.

Trace Elements

Water

Filtered-water samples collected at the four Steamboat Creek Basin sites were analyzed for 18 trace elements (Appendix C, table C–2). Only six elements—aluminum, barium, cobalt, iron, manganese, and zinc—were detected at concentrations above their MRLs (table 2). All six of these were detected in Singe Creek at concentrations generally larger than those observed at the other three sites; aluminum, barium, and zinc were detected in City Creek at concentrations larger than those observed at Horse Heaven Creek and Steamboat Creek. Of the six detected trace elements, chronic aquatic life toxicity criteria have been developed only for iron and zinc (U.S. Environmental Protection Agency, 1986); none of the detected

Table 2. Concentrations of trace elements in filtered water samples collected from the Steamboat Creek Basin, September 9-13, 1996

[Site locations are shown in figure 1; element concentrations in micrograms per liter]

Site index number	Site name	Element					
		Aluminum	Barium	Cobalt	Iron	Manganese	Zinc
1	Singe Creek	8	31	1	11	100	4
2	City Creek	4	8	<1	<3	<1	4
3	Horse Heaven Creek	2	6	<1	<3	<1	3
4	Steamboat Creek	2	2	<1	<3	<1	<1

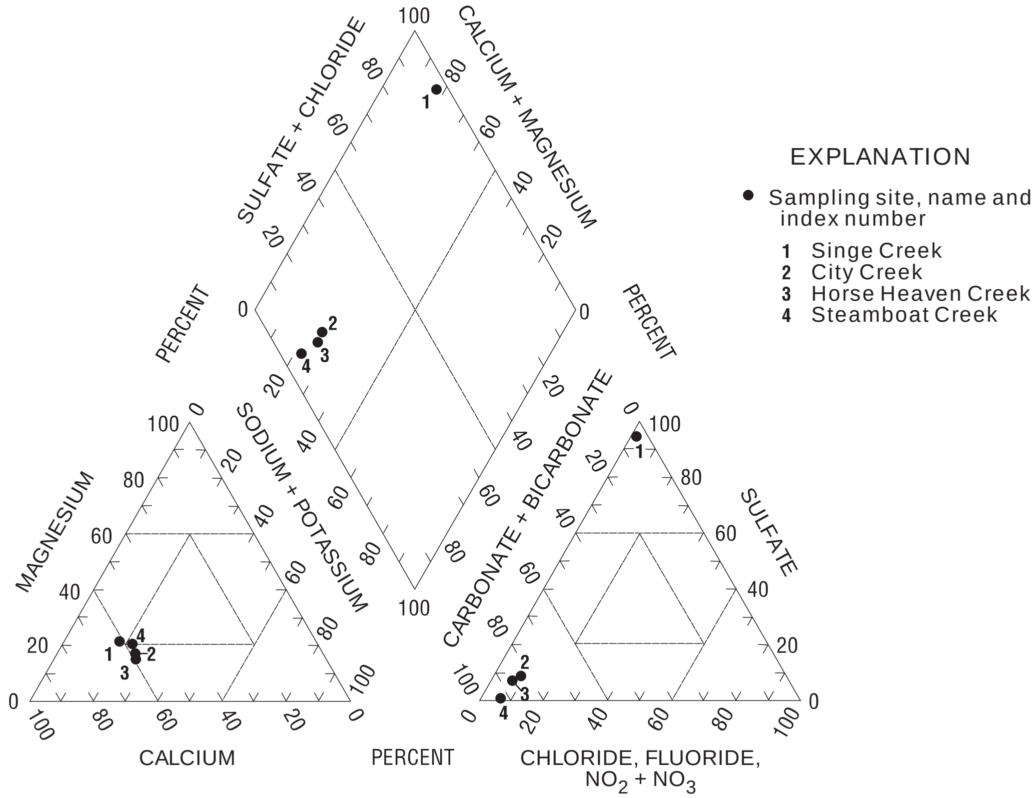

Figure 2. Trilinear diagram of major-ion concentrations in filtered water samples collected from the Steamboat Creek Basin, Oregon, September 9–13, 1996. (Numbers in figure refer to site index numbers shown in figure 1 and listed in table 1.)

concentrations exceeded the criteria levels for either iron or zinc at any site.

Bottom Sediment

Bottom sediments were analyzed for 44 trace elements plus inorganic and organic carbon (Appendix C, table C–3). Of particular interest were concentrations for 13 trace elements—antimony, arsenic, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, selenium, silver, and zinc—which are frequently associated with human activities; organic carbon content is also of interest because of its potential effect on aquatic life (Persaud and others, 1993). Bottom-sediment concentrations for antimony, arsenic, cadmium, copper, lead, mercury, zinc, and organic carbon were largest in City Creek; cobalt and selenium concentrations were largest in Singe Creek; chromium and nickel were largest in Steamboat Creek; and manganese and silver ranked highest in Horse Heaven Creek.

To determine how the trace-element concentrations at each site ranked overall against one another, concentrations for each of the 13 trace elements and organic carbon were compared among sites and each constituent assigned a ranking from 1 to 4 (smallest to largest concentration, respectively). The rankings for the 14 constituents (13 trace elements plus organic carbon) for each site were summed and their overall mean rankings computed. City Creek had the largest overall mean concentration ranking (3.2), followed by Horse Heaven Creek (2.8), Singe Creek (2.3), and Steamboat Creek (1.8), respectively. The overall mean ranking for City Creek was determined to be statistically larger ($p < 0.05$) than the mean ranking for Steamboat Creek, but not from the mean rankings of either Horse Heaven Creek or Singe Creek.

To determine whether trace-element concentrations and organic carbon content in bottom sediment from the four sites in the Steamboat Creek Basin were enriched compared with those in other areas of western Oregon, a comparison was made with concentrations observed in the Willamette River Basin, as part of the Willamette National Water-Quality Assessment (NAWQA) study, 1992–95 (Wentz and McKenzie, 1991). Normal probability plots were prepared for the 13 trace elements and organic carbon analyzed from 52 sites in the Willamette River Basin, and break-point concentrations, similar to those computed by Rickert and others (1977) and Rinella (1993), and illustrated in Appendix D, were calculated and compared to concentrations observed in the Steamboat Creek Basin (table 3). Constituent concentrations in the Steamboat Creek Basin above the Willamette River Basin break-point values were considered to be enriched. Thirteen of the 14 constituents exceeded break-point concentrations at 1 or more sites in the Steamboat Creek Basin; the only Willamette Basin break–point concentration not exceeded was for chromium. Concentrations of 11 elements in City Creek and Horse Heaven Creek—antimony, arsenic, cadmium, copper, lead, manganese (Horse Heaven Creek only), mercury, selenium, silver, zinc, and organic carbon (City Creek only)—exceeded Willamette River Basin break-point values; concentrations for 5 elements in Singe Creek—antimony, arsenic, cobalt, mercury, and selenium—exceeded Willamette River Basin break-point values; and only two elements in Steamboat Creek—antimony and nickel—exceeded Willamette River Basin break-point values (table 3).

River-bottom-sediment data from the four sites in the Steamboat Creek Basin also were compared with Canadian Council of Ministers of the Environment interim sediment-quality guidelines for the protection of aquatic life (Environment Canada, 1995). The interim Canadian sediment-quality guidelines used in this study were the threshold effects level (TEL) values, which are the concentrations below which adverse effects are expected to occur rarely to aquatic life. The TEL guideline concentrations are based on analysis of trace-element concentrations in bulk river-bottom-sediment samples as compared to the <62 μm size river-bottom-sediment materials analyzed in this study. Because the <62 μm-size fraction tends to have higher concentrations than bulk sediment, element concentrations analyzed in this study may in some instances exceed TEL guideline values solely as a result of the quantity of the fine-grained-sized materials in the sample. Consequently, trace-element concentrations exceeding the TEL guidance values should be used only as an indicator of potential sediment-quality problems that may warrant further examination. Bottom-sediment TEL concentrations have been established for only 8 of the 14 constituents discussed earlier—arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc. Bottom-sediment concentrations for these eight constituents exceeded TEL guidance values at one or more sites in the Steamboat Creek Basin (table 3). Bottom-sediment concentrations for six of the constituents in City Creek and Horse Heaven Creek—arsenic, cadmium, copper, lead, mercury, and zinc—exceeded TEL concentrations, whereas only four elements between Singe Creek and Steamboat Creek—arsenic, chromium, copper (Singe Creek only), and nickel—exceeded TEL concentrations (table 3).

SUMMARY

Four streams in the Steamboat Creek Basin, Oregon, were sampled during September 9–13, 1996, to describe current concentrations of major ions, nutrients, and trace elements in river water and bottom sediments. Three of the sites sampled were located near the mouths of tributaries to Steamboat Creek—Singe Creek, City Creek, and Horse Heaven Creek—and one site on Steamboat Creek was located farther upstream.

Streamflow and specific conductance in Singe Creek were larger than those observed at the other three sites, whereas temperature, dissolved-oxygen saturation, and pH values were smallest in Singe Creek. Examination of major-ion concentrations showed Singe Creek to be a predominantly calcium sulfate water system, whereas the other three streams were predominantly calcium bicarbonate water systems. Of the four sites examined, Singe Creek had the largest total dissolved-solids concentration, and the largest major-ion concentrations for calcium, magnesium, potassium, silica, and sulfate. Nitrogen and phosphorus concentrations (ammonia plus organic nitrogen, nitrite plus nitrate, phosphorus, and soluble reactive phosphorus) generally were smaller in Singe Creek than at the other three sites. Only six trace elements—aluminum, barium, cobalt, iron, manganese, and zinc—were detected in surface waters, and all six were detected in Singe Creek at concentrations generally larger than those observed in the other three sites.

Of the 14 constituents most frequently associated with human activities and aquatic life impacts, bottom-sediment concentrations for antimony, arsenic, cadmium, copper, lead, mercury, zinc and organic carbon were largest in City Creek. Concentrations for 11 constituents in City Creek and Horse

Table 3. Concentrations of trace elements in bottom sediment in the Steamboat Creek Basin that exceeded either Willamette River Basin break-point values or Canadian Council of Ministers of the Environment (Environmental Canada, 1995) interim threshold effect levels (TEL); TEL values are guideline concentrations below which adverse effects are expected to occur rarely to aquatic life

[For site location see figure 1. Elemental concentrations are in micrograms per gram, except for C which is in percent; Sb, antimony; As, arsenic; Cd, cadmium; Cr, chromium; Co, cobalt; Cu, copper; Pb, lead; Mn, manganese; Hg, mercury; Ni, nickel; Se, selenium; Ag, silver; Zn, zinc; and C, organic carbon; na, not available; *, less than the break-point value and the sediment-quality guideline; bold number, exceeded both the break-point value and the sediment-quality guideline. Willamette River Basin break-point concentrations based on <62 µm materials; Interim Council of Ministers of the Environment TELs guidelines based on unsieved bulk materials]

Site index no.	Site name	Element													
		Sb	As	Cd	Cr	Co	Cu	Pb	Mn	Hg	Ni	Se	Ag	Zn	C
1	Singe Creek	2.0	**23**	*	64	31	37	*	*	0.14	24	1.2	*	*	*
2	City Creek	9.0	**24**	**12**	*	*	**86**	**240**	*	**.67**	*	.4	0.8	**690**	6.75
3	Horse Heaven Creek	4.0	**22**	**3.7**	*	*	**58**	**44**	1,500	**.43**	*	.4	1.0	**430**	*
4	Steamboat Creek	2.0	10	*	92	*	*	*	*	*	**33**	*	*	*	*
	Willamette River Basin break-point values	1.3	10	.5	100	30	50	30	1,400	.11	30	.35	.3	200	6.4
	Canadian Council of Ministers of the Environment TEL guidelines	na	5.9	.596	37.3	na	35.7	35.0	na	.174	18.0	na	na	123	na

Heaven Creek—antimony, arsenic, cadmium, copper, lead, manganese (Horse Heaven Creek only), mercury, selenium, silver, zinc, and organic carbon (City Creek only)—exceeded break-point concentrations considered as levels of enrichment in the Willamette River Basin. Also, bottom-sediment concentrations for six trace elements in City Creek and Horse Heaven Creek—arsenic, cadmium, copper, lead, mercury, and zinc—exceeded interim Canadian threshold effect level concentrations established for the protection of aquatic life.

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APPENDIX A

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APPENDIX A. LIST OF CONSTITUENTS ANALYZED AND THEIR MINIMUM REPORTING LEVELS

Table A–1. List of constituents, U.S. Geological Survey laboratory codes, U.S. Environmental Protection Agency's Storage and Retrieval (STORET) database codes, and minimum reporting levels (MRLs) for constituents analyzed in the trace-element, field-blank, water sample

[Lab, laboratory; CAS, Chemical Abstracts Service; concentrations in micrograms per liter, except for calcium, magnesium, silica, and sodium which are in milligrams per liter]

Schedule 172
Category: Inorganics: Major Ions and Trace Metals

Lab code	STORET code	CAS number	Constituent	MRL
1877	01106	7429–90–5	Aluminum	0.3
1885	01049	7439–92–1	Lead	0.3
1894	01020	7440–42–8	Boron	2.0
1880	01010	7440–41–7	Beryllium	0.2
1886	01056	7439–96–5	Manganese	0.1
1892	01080	7440–24–6	Strontium	0.1
1879	01005	7440–39–3	Barium	0.2
1891	01090	7440–66–6	Zinc	0.5
1888	01065	7440–02–0	Nickel	0.5
1897	00925	7439–95–4	Magnesium	0.001
1890	22703	7440–61–1	Uranium, natural	0.2
1882	01030	7440–47–3	Chromium	0.2
1881	01025	7440–43–9	Cadmium	0.3
1887	01060	7439–98–7	Molybdenum	0.2
1899	00955	7631–86–9	Silica	0.02
1893	01057	7440–28–0	Thallium	0.1
1884	01040	7440–50–8	Copper	0.2
1895	00915	7440–70–2	Calcium	0.002
1896	01046	7439–89–6	Iron	3.0
1889	01075	7440–22–4	Silver	0.2
1878	01095	7440–36–0	Antimony	0.2
1898	00930	7440–23–5	Sodium	0.025
1883	01035	7440–48–4	Cobalt	0.2
Constituents added to schedule				
112	01000	7440–38–2	Arsenic	1.0
87	01145	7782–49–2	Selenium	1.0

APPENDIX A. LIST OF CONSTITUENTS ANALYZED AND THEIR MINIMUM REPORTING LEVELS—Continued

Table A–2. U.S. Geological Survey laboratory codes, U.S. Environmental Protection Agency Storage and Retrieval (STORET) database codes, and minimum reporting levels (MRLs) for major ion and nutrient constituents analyzed in water samples

[CAS, Chemical Abstracts Service; concentrations in milligrams per liter]

Schedule 2701
Category: Inorganics: Major Ions

Lab code	STORET code	CAS number	Constituent	MRL
663	00925	7439–95–4	Magnesium	0.01
31	00950	16984–48–8	Fluoride	0.1
667	00955	7631–86–9	Silica	0.01
1572	00945	14808–79–8	Sulfate	0.1
70	90410	471–34–1	Alkalinity	1
675	00930	7440–23–5	Sodium	0.2
27	70300		Residue, 180 degrees Celsius	1
648	01056	7439–96–5	Manganese	1
645	01046	7439–89–6	Iron	3
1571	00940	16887–00–6	Chloride	0.1
659	00915	7440–70–2	Calcium	0.02
54	00935	7440–09–7	Potassium	0.1

Schedule 1119
Category: Inorganics: Nutrients

Lab code	STORET code	CAS number	Constituent	MRL
1985	00623	17778–88–0	Nitrogen, ammonia + organic nitrogen	0.2
1979	00631		Nitrogen, nitrite + nitrate	0.005
1981	00666	7723–14–0	Phosphorus	0.001
1982	00665	7723–14–0	Phosphorus, total	0.001
1977	00613	14797–65–0	Nitrogen, nitrite	0.001
1980	00608	7664–41–7	Nitrogen, ammonia	0.002
1978	00671	14265–44–2	Phosphorus, phosphate, ortho	0.001
1986	00625	17778–88–0	Nitrogen, ammonia + organic nitrogen	0.2

APPENDIX A. LIST OF CONSTITUENTS ANALYZED AND THEIR MINIMUM REPORTING LEVELS—Continued

Table A–3. U.S. Geological Survey laboratory codes, U.S. Environmental Protection Agency Storage and Retrieval (STORET) database codes, and minimum reporting levels (MRLs) for trace elements analyzed in water samples

[CAS, Chemical Abstracts Service; concentrations in micrograms per liter]

Schedule 2703
Category: Inorganics: Trace Metals

Lab code	STORET code	CAS number	Constituent	MRL
1784	01106	7429–90–5	Aluminum	1
1785	01095	7440–36–0	Antimony	1
112	01000	7440–38–2	Arsenic	1
1786	01005	7440–39–3	Barium	1
1787	01010	7440–41–7	Beryllium	1
1788	01025	7440–43–9	Cadmium	1
1789	01030	7440–47–3	Chromium	1
1790	01035	7440–48–4	Cobalt	1
1791	01040	7440–50–8	Copper	1
1792	01049	7439–92–1	Lead	1
1793	01056	7439–96–5	Manganese	1
1794	01060	7439–98–7	Molybdenum	1
1795	01065	7440–02–0	Nickel	1
87	01145	7782–49–2	Selenium	1
1796	01075	7440–22–4	Silver	1
1797	22703	7440–61–1	Uranium, natural	1
1798	01090	7440–66–6	Zinc	1

APPENDIX A. LIST OF CONSTITUENTS ANALYZED AND THEIR MINIMUM REPORTING LEVELS—Continued

Table A–4. U.S. Geological Survey laboratory codes, U.S. Environmental Protection Agency Storage and Retrieval (STORET) database codes, and minimum reporting levels (MRLs) for trace elements analyzed in bottom-sediment samples

[CAS, Chemical Abstracts Service; concentrations in micrograms per gram (µG/G) or in percent (PCT)]

Schedule 2400
Category: Inorganics: Major Ions and Trace Metals in less than 63 micrometer bottom sediment

Lab code	STORET code	CAS number	Constituent	MRL	Reporting unit
1772	34955	7440–22–4	Silver	0.1	µG/G
1774	34910	7439–97–6	Mercury	0.02	µG/G
1753	34860	7440–55–3	Gallium	4	µG/G
1780	34970	7704–34–9	Sulfur	0.05	PCT
1778	35000	7440–61–1	Uranium	0.05	µG/G
1752	34855	7440–53–1	Europium	2	µG/G
1743	49274	7440–32–6	Titanium	0.005	PCT
1758	34915	7439–98–7	Molybdenum	2	µG/G
1751	34850	7440–50–8	Copper	1	µG/G
1771	35020	7440–66–6	Zinc	4	µG/G
1740	34900	7439–95–4	Magnesium	0.005	PCT
1754	34875	7440–60–0	Holmium	4	µG/G
1737	34830	7440–70–2	Calcium	0.005	PCT
1756	34895	7439–93–2	Lithium	2	µG/G
1773	34825	7440–43–9	Cadmium	0.1	µG/G
1736	34790	7429–90–5	Aluminum	0.005	PCT
1742	34935	7723–14–0	Phosphorus	0.005	PCT
1770	35015	7440–64–4	Ytterbium	1	µG/G
1762	34890	7439–92–1	Lead	4	µG/G
1779	34980	7440–29–1	thorium	1	µG/G
1766	34975		Tantalum	40	µG/G
1763	34945	7440–20–2	Scandium	2	µG/G
1760	34920	7440–00–8	Neodymium	4	µG/G
1776	34795	7440–36–0	Antimony	0.1	µG/G
1748	34835	7440–45–1	Cerium	4	µG/G
1775	34800	7440–38–2	Arsenic	0.1	µG/G
1759	34930	7440–03–1	Niobium	4	µG/G
1765	34965	7440–24–6	Strontium	2	µG/G
1747	34816	7440–69–9	Bismuth	10.	µG/G
1741	34960	7440–23–5	Sodium	0.005	PCT
1761	34925	7440–02–0	Nickel	2	µG/G
1745	34805	7440–39–3	Barium	1	µG/G
1768	35005	7440–62–2	Vanadium	2	µG/G
1782	49269		Inorganic carbon	0.01	PCT
1755	34885	7439–91–0	Lanthanum	2	µG/G
1777	34950	7782–49–2	Selenium	0.1	µG/G
1744	34870	7440–57–5	Gold	8	µG/G
1749	34845	7440–47–3	Chromium	1	µG/G
1783	49266		Organic carbon	0.01	PCT
1764	34985	7440–31–5	Tin	5	µG/G
1739	34940	7440–09–7	Potassium	0.05	PCT
1781	49267		Total carbon	0.01	PCT
1750	34840	7440–48–4	Cobalt	1	µG/G
1769	35010	7440–65–5	Yttrium	2	µ/G
1746	34810	7440–41–7	Beryllium	1	µG/G
1757	34905	7439–96–5	Manganese	4	µG/G
1738	34880	7439–89–6	Iron	0.005	PCT

APPENDIX B

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APPENDIX B. CHEMICAL ANALYSIS OF THE QUALITY ASSURANCE SAMPLES

Table B–1. Concentrations of trace elements in field-blank water sample

[Dissolved, operationally defined as water that has been passed though a 0.45 micrometer filter; constituent concentrations in MG/L, milligrams per liter or µG/L, micrograms per liter; number in parenthesis is the U.S. Environmental Protection Agency Storage and Retrieval (STORET) database code]

STATION NUMBER	STATION NAME	DATE	TIME	CALCIUM DIS-SOLVED (MG/L AS CA) (00915)
433003122354900	CITY CREEK NR. STEAMBOAT, OR	09–09–96	1408	0.003

STATION NUMBER	DATE	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG) (00925)	SODIUM, DIS-SOLVED (MG/L AS NA) (00930)	SILICA, DIS-SOLVED (MG/L AS SIO2) (00955)	ALUM-INUM, DIS-SOLVED (µG/L AS AL) (01106)	ANTI-MONY, DIS-SOLVED (µG/L AS SB) (01095)	ARSENIC DIS-SOLVED (µG/L AS AS) (01000)	BARIUM, DIS-SOLVED (µG/L AS BA) (01005)	BERYL-LIUM, DIS-SOLVED (µG/L AS BE) (01010)
433003122354900	09–09–96	<0.001	<0.03	0.033	<0.3	<0.2	<1	<0.2	<0.2

STATION NUMBER	DATE	BORON, DIS-SOLVED (µG/L AS B) (01020)	CADMIUM DIS-SOLVED (µG/L AS CD) (01025)	CHRO-MIUM, DIS-SOLVED (µG/L AS CR) (01030)	COBALT, DIS-SOLVED (µG/L AS CO) (01035)	COPPER, DIS-SOLVED (µG/L AS CU) (01040)	IRON, DIS-SOLVED (µG/L AS FE) (01046)	LEAD, DIS-SOLVED (µG/L AS PB) (01049)	MANGA-NESE, DIS-SOLVED (µG/L AS MN) (01056)
433003122354900	09–09–96	<2	<0.3	<0.2	<0.2	<0.2	<3	<0.3	<0.1

STATION NUMBER	DATE	THAL-LIUM, DIS-SOLVED (µG/L AS TL) (01057)	MOLYB-DENUM, DIS-SOLVED (µG/L AS MO) (01060)	NICKEL, DIS-SOLVED (µG/L AS NI) (01065)	SELE-NIUM, DIS-SOLVED (µG/L AS SE) (01145)	SILVER, DIS-SOLVED (µG/L AS AG) (01075)	STRON-TIUM, DIS-SOLVED (µG/L AS SR) (01080)	ZINC, DIS-SOLVED (µG/L AS ZN) (01090)	URANIUM NATURAL DIS-SOLVED (µG/L AS U) (22703)
433003122354900	09–09–96	<0.1	<0.2	<0.5	<1	<0.2	<0.1	0.92	<0.2

APPENDIX B. CHEMICAL ANALYSIS OF THE QUALITY ASSURANCE SAMPLES—Continued

Table B–2. Concentrations of nutrients, major ions, and trace elements in field split sample

[Dissolved, operationally defined as water that has been passed though a 0.45 micrometer filter; constituent concentrations in MG/L, milligrams per liter or µG/L, micrograms per liter; number in parenthesis is the U.S. Environmental Protection Agency Storage and Retrieval (STORET) database code]

STATION NUMBER	STATION NAME	DATE	TIME	NITROGEN, AMMONIA DISSOLVED (MG/L AS N) (00608)	NITROGEN, NITRITE DISSOLVED (MG/L AS N) (00613)	NITROGEN, AMMONIA + ORGANIC DIS. (MG/L AS N) (00623)
433044122345300	HORSE HEAVEN CREEK NR. STEAMBOAT	09–11–96	1112	<0.002	0.003	<0.2

STATION NUMBER	DATE	NITROGEN, AMMONIA + ORGANIC TOTAL (MG/L AS N) (00625)	NITROGEN, NO2+NO3 DISSOLVED (MG/L AS N) (00631)	PHOSPHORUS TOTAL (MG/L AS P) (00665)	PHOSPHORUS DISSOLVED (MG/L AS P) (00666)	PHOSPHORUS ORTHO, DISSOLVED (MG/L AS P) (00671)	HARDNESS TOTAL (MG/L AS CACO3) (00900)	CALCIUM DISSOLVED (MG/L AS CA) (00915)	MAGNESIUM, DISSOLVED (MG/L AS MG) (00925)	SODIUM, DISSOLVED (MG/L AS NA) (00930)
433044122345300	09–11–96	<0.2	0.032	0.017	0.015	0.010	25	7.8	1.3	3.6

STATION NUMBER	DATE	SODIUM ADSORPTION RATIO (00931)	SODIUM PERCENT (00932)	POTASSIUM, DISSOLVED (MG/L AS K) (00935)	CHLORIDE, DISSOLVED (MG/L AS CL) (00940)	SULFATE DISSOLVED (MG/L AS SO4) (00945)	FLUORIDE, DISSOLVED (MG/L AS F) (00950)	SILICA, DISSOLVED (MG/L AS SIO2) (00955)	SOLIDS, RESIDUE AT 180 DEG. C DISSOLVED (MG/L) (70300)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (MG/L) (70301)
433044122345300	09–11–96	0.3	24	0.5	1.3	2.2	<0.1	13	47	47

STATION NUMBER	STATION NAME	DATE	TIME	ALUMINUM, DISSOLVED (µG/L AS AL) (01106)	ANTIMONY, DISSOLVED (µG/L AS SB) (01095)
433044122345300	HORSE HEAVEN CREEK NR. STEAMBOAT	09–11–96	1113	3.0	<1

STATION NUMBER	DATE	ARSENIC DISSOLVED (µG/L AS AS) (01000)	BARIUM, DISSOLVED (µG/L AS BA) (01005)	BERYLLIUM, DISSOLVED (µG/L AS BE) (01010)	CADMIUM DISSOLVED (µG/L AS CD) (01025)	CHROMIUM, DISSOLVED (µG/L AS CR) (01030)	COBALT, DISSOLVED (µG/L AS CO) (01035)	COPPER, DISSOLVED (µG/L AS CU) (01040)	IRON, DISSOLVED (µG/L AS FE) (01046)
433044122345300	09–11–96	<1	5	<1	<1	<1	<1	<1	<3

STATION NUMBER	DATE	LEAD, DISSOLVED (µG/L AS PB) (01049)	MANGANESE, DISSOLVED (µG/L AS MN) (01056)	MOLYBDENUM, DISSOLVED (µG/L AS MO) (01060)	NICKEL, DISSOLVED (µG/L AS NI) (01065)	SELENIUM, DISSOLVED (µG/L AS SE) (01145)	SILVER, DISSOLVED (µG/L AS AG) (01075)	ZINC, DISSOLVED (µG/L AS ZN) (01090)	URANIUM NATURAL DISSOLVED (µG/L AS U) (22703)
433044122345300	09–11–96	<1	<1	<1	<1	<1	<1	5	<1

APPENDIX B. CHEMICAL ANALYSIS OF THE QUALITY ASSURANCE SAMPLES—Continued

Table B–3. Concentrations of trace elements in less than (<) 2 millimeter (MM) bottom sediment
[Concentrations in µG/G (micrograms per gram) or in PERCENT; WS, wet sieved]

STATION NUMBER	STATION NAME	DATE	TIME	ALUM- INUM <2MM WS FIELD PERCENT	ANTI- MONY <2MM WS FIELD (µG/G)
433044122345300	HORSE HEAVEN CREEK NR. STEAMBOAT	09–11–96	1112	7.7	6.0

STATION NUMBER	DATE	ARSENIC <2MM WS FIELD (µG/G)	BARIUM <2MM WS FIELD (µG/G)	BERYL- LIUM <2MM WS FIELD (µG/G)	BISMUTH <2MM WS FIELD (µG/G)	CADMIUM <2MM WS FIELD (µG/G)	CALCIUM <2MM WS FIELD PERCENT	CERIUM <2MM WS FIELD (µG/G)	CHRO- MIUM <2MM WS FIELD (µG/G)	COBALT <2MM WS FIELD (µG/G)
433044122345300	09–11–96	24	410	1	<10	1.2	2.0	25	35	17

STATION NUMBER	DATE	COPPER <2MM WS FIELD (µG/G)	EURO- PIUM <2MM WS FIELD (µG/G)	GALLIUM <2MM WS FIELD (µG/G)	GOLD <2MM WS FIELD (µG/G)	HOLMIUM <2MM WS FIELD (µG/G)	IRON <2MM WS FIELD PERCENT	LANTHA- NUM <2MM WS FIELD (µG/G)	LEAD <2MM WS FIELD (µG/G)	LITHIUM <2MM WS FIELD (µG/G)
433044122345300	09–11–96	32	<2	18	<8	<4	5.4	16	40	30

STATION NUMBER	DATE	MAGNE- SIUM <2MM WS FIELD PERCENT	MANGA- NESE <2MM WS FIELD (µG/G)	MERCURY <2MM WS FIELD (µG/G)	MOLYB- DENUM <2MM WS FIELD (µG/G)	NEODYM- IUM <2MM WS FIELD (µG/G)	NICKEL <2MM WS FIELD (µG/G)	NIOBIUM <2MM WS FIELD (µG/G)	PHOS- PHORUS <2MM WS FIELD PERCENT	POTAS- SIUM <2MM WS FIELD PERCENT
433044122345300	09–11–96	0.97	1200	0.21	<2	14	10	10	0.07	1.0

STATION NUMBER	DATE	SCAN- DIUM <2MM WS FIELD (µG/G)	SELE- NIUM <2MM WS FIELD (µG/G)	SILVER <2MM WS FIELD (µG/G)	SODIUM <2MM WS FIELD PERCENT	STRON- TIUM <2MM WS FIELD (µG/G)	SULFUR <2MM WS FIELD (µG/G)	TANTA- LUM <2MM WS FIELD (µG/G)	THORIUM <2MM WS FIELD (µG/G)	TIN <2MM WS FIELD (µG/G)
433044122345300	09–11–96	19	0.1	0.3	1.8	290	<0.05	<40	<3	<5

STATION NUMBER	DATE	TITA- NIUM, SED, BM WS,<2MM DRY WGT REC PERCENT	URANIUM BOT MAT <2MM WS FIELD (µG/G)	VANA- DIUM BOT MAT <2MM WS FIELD (µG/G)	YTTRIUM BOT MAT <2MM WS FIELD (µG/G)	YTTER- BIUM BOT MAT <2MM WS FIELD (µG/G)	ZINC BOT MAT <2MM WS FIELD (µG/G)	CARBON, ORGANIC SED, BM WS,<2MM DW, REC (PER- CENT)	CARBON, INORG, SED, BM WS,<2MM DW, REC (PER- CENT)	CARBON, ORG + INORG, SED, BM WS,<2MM DW, REC PERCENT
433044122345300	09–11–96	0.580	1.7	130	24	2	290	0.31	0.01	0.32

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APPENDIX C

APPENDIX C. CHEMICAL ANALYSIS OF THE ENVIRONMENTAL SAMPLES

Table C–1. Field measurements, and concentrations of nutrients and major ions in unfiltered and filtered water samples collected from the Steamboat Creek Basin, 1996

[DEG C, degrees Celsius; MM OF HG, millimeters of mercury; µS/CM microSiemens per centimeter at 25 degrees Celsius; MG/L, milligrams per liter; CO3, carbonate; HCO3, bicarbonate; CACO3, calcium carbonate; dissolved, operationally defined as water which has passed through a 0.45 micrometer filter; number in parenthesis is the U.S. Environmental Protections Agency Storage and Retrieval (STORET) database code]

STATION NUMBER	STATION NAME	DATE	TIME	TEMPERATURE WATER (DEG C) (00010)	BAROMETRIC PRESSURE (MM OF HG) (00025)	DISCHARGE, INST. CUBIC FEET PER SECOND (00061)
432213122370000	SINGE CREEK NR. STEAMBOAT	09–13–96	1020	12.1	703	1.81
433003122354900	CITY CREEK NR. STEAMBOAT, OR	09–09–96	1400	15.0	705	0.71
433044122345300	HORSE HEAVEN CREEK NR. STEAMBOAT	09–11–96	1110	13.1	704	1.23
433042122344800	STEAMBOAT CREEK NR. STEAMBOAT	09–12–96	1110	12.9	702	1.67

STATION NUMBER	DATE	SPECIFIC CONDUCTANCE (µS/CM) (00095)	OXYGEN, DISSOLVED (MG/L) (00300)	OXYGEN, DISSOLVED (PERCENT SATURATION) (00301)	PH WATER WHOLE FIELD (STANDARD UNITS) (00400)	CARBONATE WATER DIS IT FIELD MG/L AS CO3 (00452)	BICARBONATE WATER DIS IT FIELD MG/L AS HCO3 (00453)	ALKALINITY WAT DIS TOT IT FIELD MG/L AS CACO3 (39086)	NITROGEN, AMMONIA DISSOLVED (MG/L AS N) (00608)	NITROGEN, NITRITE DISSOLVED (MG/L AS N) (00613)	NITROGEN,AMMONIA + ORGANIC DIS. (MG/L AS N) (00623)
432213122370000	09–13–96	154	9.4	95	7.3	<1	3	3	<0.002	0.002	<0.2
433003122354900	09–09–96	43	9.2	99	7.7	<1	22	18	<0.002	0.002	<0.2
433044122345300	09–11–96	62	9.3	96	7.7	<1	34	28	<0.002	0.003	<0.2
433042122344800	09–12–96	98	9.5	98	8.1	<1	61	50	<0.002	0.003	<0.2

STATION NUMBER	DATE	NITROGEN,AMMONIA + ORGANIC TOTAL (MG/L AS N) (00625)	NITROGEN, NO2+NO3 DISSOLVED (MG/L AS N) (00631)	PHOSPHORUS TOTAL (MG/L AS P) (00665)	PHOSPHORUS DISSOLVED (MG/L AS P) (00666)	PHOSPHORUS ORTHO, DISSOLVED (MG/L AS P) (00671)	HARDNESS TOTAL (MG/L AS CACO3) (00900)	CALCIUM DISSOLVED (MG/L AS CA) (00915)	MAGNESIUM, DISSOLVED (MG/L AS MG) (00925)	SODIUM, DISSOLVED (MG/L AS NA) (00930)
432213122370000	09–13–96	<0.2	<0.005	0.002	<0.001	<0.001	54	16	3.4	4.6
433003122354900	09–09–96	<0.2	0.014	0.008	0.007	<0.001	16	5.0	0.87	2.2
433044122345300	09–11–96	<0.2	0.032	0.016	0.015	0.010	25	7.9	1.3	3.6
433042122344800	09–12–96	<0.2	<0.005	0.036	0.028	0.021	41	12	2.6	5.0

STATION NUMBER	DATE	SODIUM ADSORPTION RATIO (00931)	SODIUM PERCENT (00932)	POTASSIUM, DISSOLVED (MG/L AS K) (00935)	CHLORIDE, DISSOLVED (MG/L AS CL) (00940)	SULFATE DISSOLVED (MG/L AS SO4) (00945)	FLUORIDE, DISSOLVED (MG/L AS F) (00950)	SILICA, DISSOLVED (MG/L AS SIO2) (00955)	SOLIDS, RESIDUE AT 180 DEG. C DISSOLVED (MG/L) (70300)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (MG/L) (70301)
432213122370000	09–13–96	0.3	15	1.0	0.7	59	<0.1	23	112	109
433003122354900	09–09–96	0.2	22	0.4	1.1	1.8	<0.1	7.7	26	30
433044122345300	09–11–96	0.3	23	0.5	1.3	2.2	<0.1	13	44	47
433042122344800	09–12–96	0.3	21	0.5	2.1	0.5	<0.1	19	66	72

APPENDIX C. CHEMICAL ANALYSIS OF THE ENVIRONMENTAL SAMPLES—Continued

Table C–2. Concentrations of trace elements in filtered water samples collected from the Steamboat Creek Basin, 1996
[DISSOLVED, operationally defined as water that has passed through a 0.45 micrometer filter; µG/L, micrograms per liter; number in parenthesis is the U.S. Environmental Protection Agency Storage and Retrieval (STORET) database code]

STATION NUMBER	STATION NAME	DATE	TIME	ALUM-INUM, DIS-SOLVED (µG/L AS AL (01106)	ANTI-MONY, DIS-SOLVED (µG/L AS SB) (01095)
432213122370000	SINGE CREEK NR. STEAMBOAT	09–13–96	1021	8	<1
433003122354900	CITY CREEK NR. STEAMBOAT, OR	09–09–96	1401	4	<1
433044122345300	HORSE HEAVEN CREEK NR. STEAMBOAT	09–11–96	1111	2	<1
433042122344800	STEAMBOAT CREEK NR. STEAMBOAT	09–12–96	1111	2	<1

STATION NUMBER	DATE	ARSENIC DIS-SOLVED (µG/L AS AS) (01000)	BARIUM, DIS-SOLVED (µG/L AS BA) (01005)	BERYL-LIUM, DIS-SOLVED (µG/L AS BE) (01010)	CADMIUM DIS-SOLVED (µG/L AS CD) (01025)	CHRO-MIUM, DIS-SOLVED (µG/L AS CR) (01030)	COBALT, DIS-SOLVED (µG/L AS CO) (01035)	COPPER, DIS-SOLVED (µG/L AS CU) (01040)	IRON, DIS-SOLVED (µG/L AS FE) (01046)
432213122370000	09–13–96	<1	31	<1	<1	<1	1	<1	11
433003122354900	09–09–96	<1	8	<1	<1	<1	<1	<1	<3
433044122345300	09–11–96	<1	6	<1	<1	<1	<1	<1	<3
433042122344800	09–12–96	<1	2	<1	<1	<1	<1	<1	<3

STATION NUMBER	DATE	LEAD, DIS-SOLVED (µG/L AS PB) (01049)	MANGA-NESE, DIS-SOLVED (µG/L AS MN) (01056)	MOLYB-DENUM, DIS-SOLVED (µG/L AS MO) (01060)	NICKEL, DIS-SOLVED (µG/L AS NI) (01065)	SELE-NIUM, DIS-SOLVED (µG/L AS SE) (01145)	SILVER, DIS-SOLVED (µG/L AS AG) (01075)	ZINC, DIS-SOLVED (µG/L AS ZN) (01090)	URANIUM NATURAL DIS-SOLVED (µG/L AS U) (22703)
432213122370000	09–13–96	<1	109	<1	<1	<1	<1	4	<1
433003122354900	09–09–96	<1	<1	<1	<1	<1	<1	4	<1
433044122345300	09–11–96	<1	<1	<1	<1	<1	<1	3	<1
433042122344800	09–12–96	<1	<1	<1	<1	<1	<1	<1	<1

Table C–3. Concentrations of trace elements in less than (<) 63 micrometer bottom sediment from the Steamboat Creek Basin, 1996

[Concentrations in µG/G, micrograms per gram or in PERCENT; WS, wet sieved; number in parenthesis is the U.S. Environmental Protection Agency Storage and Retrieval (STORET) database code]

STATION NUMBER	STATION NAME	DATE	TIME	ALUMINUM <63U WS FIELD PERCENT (34790)	ANTIMONY <63U WS FIELD (µG/G) (34795)
432213122370000	SINGE CREEK NR. STEAMBOAT	09–13–96	1020	9.3	2
433003122354900	CITY CREEK NR. STEAMBOAT, OR	09–09–96	1400	7.5	9
433044122345300	HORSE HEAVEN CREEK NR. STEAMBOAT	09–11–96	1110	8.1	4
433042122344800	STEAMBOAT CREEK NR. STEAMBOAT	09–12–96	1110	8.7	2

STATION NUMBER	DATE	ARSENIC <63U WS FIELD (µG/G) (34800)	BARIUM <63U WS FIELD (µG/G) (34805)	BERYLLIUM <63U WS FIELD (µG/G) (34810)	BISMUTH <63U WS FIELD (µG/G) (34816)	CADMIUM <63U WS FIELD (µG/G) (34825)	CALCIUM <63U WS FIELD PERCENT (34830)	CERIUM <63U WS FIELD (µG/G) (34835)	CHROMIUM <63U WS FIELD (µG/G) (34840)	COBALT <63U WS FIELD (µG/G) (34845)
432213122370000	09–13–96	23	470	1	<10	0.3	0.81	43	64	31
433003122354900	09–09–96	24	390	1	<10	12	1.2	39	30	16
433044122345300	09–11–96	22	410	1	<10	3.7	1.5	39	32	18
433042122344800	09–12–96	10	350	1	<10	0.2	1.7	33	92	20

STATION NUMBER	DATE	COPPER <63U WS FIELD (µG/G) (34850)	EUROPIUM <63U WS FIELD (µG/G) (34855)	GALLIUM <63U WS FIELD (µG/G) (34860)	GOLD <63U WS FIELD (µG/G) (34870)	HOLMIUM <63U WS FIELD (µG/G) (34875)	IRON <63U WS FIELD PERCENT (34880)	LANTHANUM <63U WS FIELD (µG/G) (34885)	LEAD <63U WS FIELD (µG/G) (34890)	LITHIUM <63U WS FIELD (µG/G) (34895)
432213122370000	09–13–96	37	<2	18	<8	<4	4.9	25	19	30
433003122354900	09–09–96	86	<2	17	<8	<4	5.0	25	240	40
433044122345300	09–11–96	58	<2	20	<8	<4	5.6	24	44	40
433042122344800	09–12–96	25	<2	21	<8	<4	5.8	20	14	40

STATION NUMBER	DATE	MAGNESIUM <63U WS FIELD PERCENT (34900)	MANGANESE <63U WS FIELD (µG/G) (34905)	MERCURY <63U WS FIELD (µG/G) (34910)	MOLYBDENUM <63U WS FIELD (µG/G) (34915)	NEODYMIUM <63U WS FIELD (µG/G) (34920)	NICKEL <63U WS FIELD (µG/G) (34925)	NIOBIUM <63U WS FIELD (µG/G) (34930)	PHOSPHORUS <63U WS FIELD PERCENT (34935)	POTASSIUM <63U WS FIELD PERCENT (34940)
432213122370000	**09–13–96**	**0.78**	**900**	**0.14**	**<2**	**24**	**24**	**9**	**0.08**	**1.1**
433003122354900	**09–09–96**	**0.74**	**1200**	**0.67**	**<2**	**29**	**11**	**10**	**0.15**	**0.81**
433044122345300	**09–11–96**	**0.91**	**1500**	**0.43**	**<2**	**27**	**10**	**11**	**0.11**	**0.81**
433042122344800	**09–12–96**	**1.3**	**990**	**0.06**	**<2**	**22**	**33**	**12**	**0.07**	**0.63**

Table C–3. Concentrations of trace elements in less than (<) 63 micrometer bottom sediment from the Steamboat Creek Basin, 1996—Continued

STATION NUMBER	DATE	SCANDIUM <63U WS FIELD (µG/G) (34945)	SELENIUM <63U WS FIELD (µG/G) (34950)	SILVER <63U WS FIELD (µG/G) (34955)	SODIUM <63U WS FIELD PERCENT (34960)	STRONTIUM <63U WS FIELD (µG/G) (34965)	SULFUR <63U WS FIELD (µG/G) (34970)	TANTALUM <63U WS FIELD (µG/G) (34975)	THORIUM <63U WS FIELD (µG/G) (34980)	TIN <63U WS FIELD (µG/G) (34985)
432213122370000	09–13–96	20	1.2	0.2	0.51	150	0.09	<40	7	<5
433003122354900	09–09–96	21	0.4	0.8	1.0	140	0.09	<40	4	<5
433044122345300	09–11–96	24	0.4	1.0	0.96	210	0.05	<40	6	<5
433042122344800	09–12–96	25	0.2	0.1	0.92	250	<0.05	<40	5	<5

STATION NUMBER	DATE	TITANIUM, <63U WS FIELD PERCENT (49274)	URANIUM <63U WS FIELD (µG/G) (35000)	VANADIUM <63U WS FIELD (µG/G) (35005)	YTTRIUM <63U WS FIELD (µG/G) (35010)	YTTERBIUM <63U WS FIELD (µG/G) (35015)	ZINC <63U WS FIELD (µG/G) (35020)	CARBON ORGANIC <63U WS (PERCENT) (49266)	CARBON, CARBON, INORG, <63U WS (PERCENT) (49269)	ORG + INORG, <63U WS (PERCENT) (49267)
432213122370000	09–13–96	0.500	3.0	160	24	2	110	1.98	0.02	2.00
433003122354900	09–09–96	0.470	1.6	120	33	2	690	6.75	0.03	6.78
433044122345300	09–11–96	0.680	1.7	130	37	3	430	3.93	0.02	3.95
433042122344800	09–12–96	0.760	1.4	140	35	3	95	3.12	0.02	3.14

APPENDIX D

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APPENDIX D. EXPLANATION OF CALCULATIONS FOR DETERMINING BREAK-POINT CONCENTRATIONS FOR CONSTITUENTS IN WILLAMETTE RIVER BASIN BOTTOM SEDIMENT

The technique used to distinguish whether constituent concentrations in bottom sediment from four sites in the Steamboat Creek Subbasin were at background or enriched levels (naturally or because of human activities) was derived from previous work in the Willamette River Basin by Rickert and others (1977). For this report, the work done by Rickert and others was updated using bottom-sediment data collected in the Willamette River Basin from 1992–95 as part of three studies: (1) a cooperative study with the Oregon Department of Environmental Quality in the Willamette River Basin, (2) a cooperative study with the Unified Sewerage Agency of Washington County in the Tualatin River Basin, and (3) a U.S. Geological Survey National Water-Quality Assessment Program in the Willamette Basin. In these studies, bottom-sediment samples were collected from 52 sites and processed using methods outlined by Shelton and Capel (1994), and analyzed according to methods described by Arbogast (1990). Normal-probability plots showing constituent concentrations were constructed using the compiled data. If the concentrations derived for a particular constituent were from natural weathering of chemically related rock types, the concentrations would be expected to form one statistical population, represented by a straight line, on a normal-probability plot. If part of the constituent's population was derived either from human-derived sources or from unique geologic sources (for example, enrichment from cinnabar deposits), a second statistical population, as represented by a second straight line, might occur on the same normal-probability plot. A break in the two lines would then be observed between the background concentrations (the lower line) and the enriched concentrations (the upper line); the point where the two lines meet (intersect) on the plot is known as the break-point concentration. For example, the break-point concentration for silver in bottom-sediment collected in the Willamette River Basin during 1992–95 was determined to be 0.3 µg/g (micrograms per gram) (fig. D–1). Rickert and others (1977) showed that constituent concentrations at or below the break-point concentrations were similar to concentrations measured in uncontaminated soils in the Willamette River Basin.

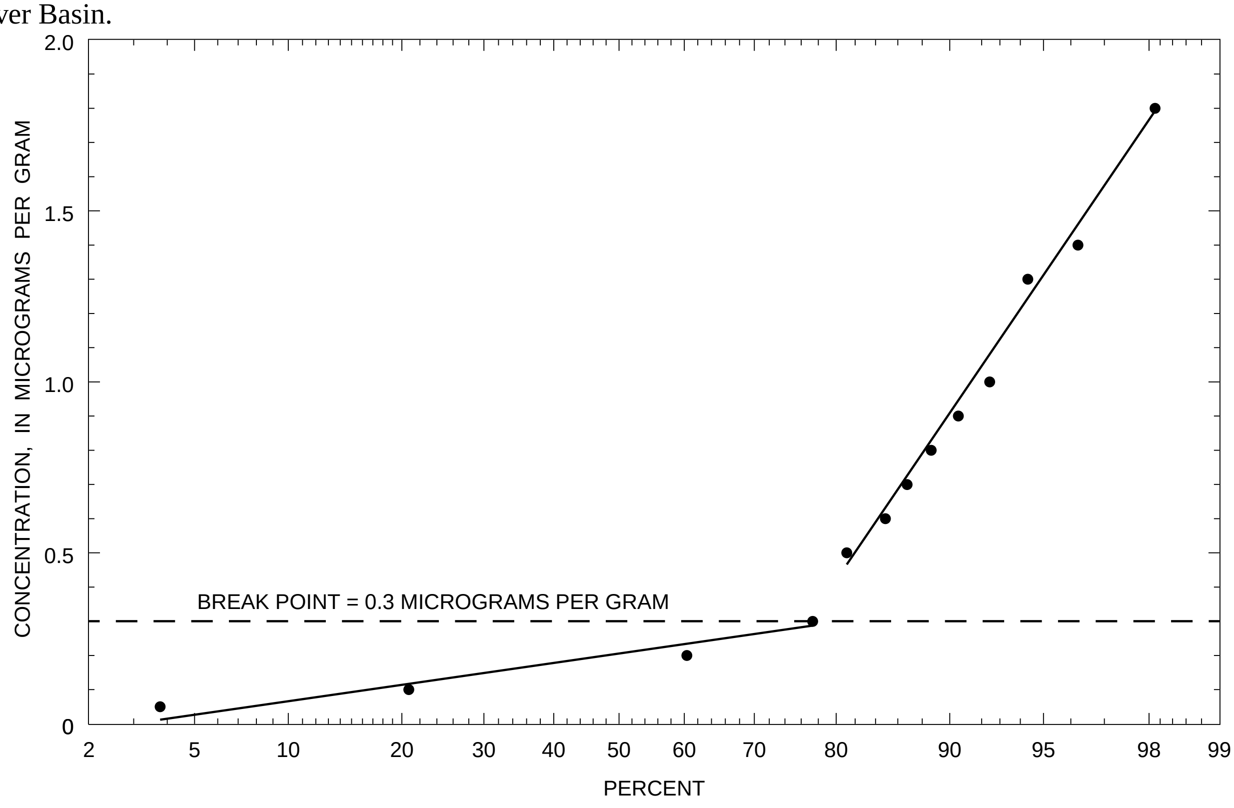

Figure D-1. Normal-probability plot of silver concentrations in less than 62 micrometer-size bottom sediment from the Willamette River Basin, Oregon, 1992–95.

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