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

Selected Elements and Organic Chemicals in Streambed Sediment in the Salem Area, Oregon, 1999

Water-Resources Investigations Report 02–4194

Prepared in cooperation with
the City of Salem

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COVER PHOTOGRAPHS:

Left: Gibson Creek near mouth, looking north.

Upper: Glenn Creek upstream from Gibson Creek, looking north.

Lower: Mill Creek upstream from Mill Race, looking east.

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By DWIGHT Q. TANNER

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Portland, Oregon
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CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATIONS

Multiply	By	To obtain
feet	0.3048	meters
miles	1.609	kilometers
square miles	12.590	square kilometers
degrees Fahrenheit (°F)[1]		degrees Celsius (°C)

[1]Temperature °F = 1.8 (Temperature °C) + 32.

ABBREVIATIONS

Certain measurements used in this report are given only in metric units:

mL, milliliter
mm, millimeter
µm, micrometer
g, gram
mg/L, milligrams per liter
µg/g, micrograms per gram
µg/kg, micrograms per kilogram

Selected Elements and Organic Chemicals in Streambed Sediment in the Salem Area, Oregon, 1999

By Dwight Q. Tanner

Abstract

Analysis of streambed sediments in the Salem, Oregon, area showed anomalously large concentrations of some elements and organic chemicals, indicating contamination from anthropogenic and/or geologic sources. The streambed sediment sample from Clark Creek, an urban basin, had large concentrations of polycyclic aromatic hyrdocarbons (PAHs), organochlorines, cadmium, lead, and zinc. The sample from the East Fork of Pringle Creek, which is a mostly urban basin, had the highest concentrations of DDD, DDE, and DDT compounds. Aldrin was detected in streambed sediment at only one site, the East Fork of Pringle Creek. Ten of the 14 sites sampled had exceedances of the sediment quality guidelines of the Canadian Council of Ministers of the Environment (CCME), and 8 sites had exceedances of guidelines from the Puget Sound Dredged Disposal Analysis (PSDDA) Program.

Trace element concentrations in the Salem area generally were similar to those found previously in the Willamette Basin and nationally. However, cadmium, lead, and zinc concentrations were larger in the sample from Clark Creek than for largest value for Willamette Basin data from earlier studies. Zinc concentrations in the sample from Clark Creek exceeded sediment quality guidelines from the CCME and PSDDA.

p,p'-DDE, which is a persistent breakdown product of the banned organochlorine-insecticide, DDT, was detected at all sites. Total DDT (the sum of *p,p'*-DDD, *p,p'*-DDE, and *p,p'*-DDT) concentrations exceeded the PSDDA screening level at eight sites and exceeded twice the PSDDA maximum level at the East Fork of Pringle Creek. *Cis*- and *trans*-chlordanes were detected at about 80% of the sites. The concentration of total chlordane for the sample at Clark Creek was larger than for any sample from previous Willamette Basin studies. The largest concentration of dieldrin also was from the sample at Clark Creek, which was the only site that exceeded the CCME guideline for dieldrin.

The high levels of contaminants in some Salem-area streams indicates the need for further study to assess the biological effects of these contaminants. Future monitoring in the Salem area could include bioassays using benthic invertebrates and the measurement of organochlorine compounds, including DDT, DDE, DDD, and dieldrin in fish tissue. Because resident fish may be consumed by humans and wildlife, fish tissue analyses would be helpful to determine the health risk associated with fish consumption.

INTRODUCTION

The mobility and fate of contaminants associated with streambed sediment depend on the mobility of the sediment and on the chemical and physical characteristics of the contaminants. Contaminants may be transported, deposited, and resuspended in response to different hydrological conditions; some can also dissociate from the sediment and be transported in the dissolved phase. The two main reasons for analyzing the streambed sediment for trace elements and hydrophobic (water avoiding) organic chemicals are that (1) fine-grained particles and organic matter are accumulators of trace elements and hydrophobic organic chemicals, and (2) streambed sediments in depositional environments provide a time-integrated sample of intermittent or storm-related contaminants. The analysis of streambed sediments is also useful for considering potential biological impacts (Kennicutt and others, 1994).

Major elements such as iron, aluminum, calcium, magnesium, and potassium occur naturally in the rocks and minerals in a watershed and therefore are present in streambed sediment. Minor, or trace, elements also occur naturally, but at smaller concentrations than major elements. Trace elements generally are considered to be elements that occur dissolved in natural waters at concentrations less than 1.0 mg/L (milligrams per liter) (Hem, 1992, p. 129). Natural sources of elements include the dissolution and disaggregation of soils and geologic materials. Human-induced sources include agriculture, mining, manufacturing, municipal waste, urban runoff, and the burning of fossil fuels. Some trace elements are beneficial or essential to plants and animals in small concentrations, yet are toxic in large concentrations.

The organic chemicals studied in this report are predominantly from anthropogenic sources, and their presence in the environment has increased with the production and widespread use of these chemicals. Organochlorine pesticides were some of the first organic pesticides developed, but their production has decreased because their use has become regulated or banned in the United States. The agricultural uses of chlordane, dieldrin, and dichlorodiphenyltrichloroethane (DDT) were banned in the early 1970s (U.S. Environmental Protection Agency, 1985), but chlordane was used for termite control until the late 1980s. Organochlorine pesticides have a low solubility in water and a high environmental persistence (Witkowski and others, 1987).

Polychlorinated biphenyls (PCBs) are synthetic compounds that were widely used in electrical transformers in the 1960s and 1970s, but PCBs were banned in 1979. Like organochlorine pesticides, PCBs are almost insoluble in water and persist in the environment, so they can become concentrated in streambed sediment.

Polycyclic aromatic hydrocarbons (PAHs) also have low water solubilities and partition into the organic matter in streambed sediments. PAHs are produced by fuel spills, waste incineration, and fossil fuel combustion. Several are carcinogens or mutagens (Smith and others, 1988). PAHs generally are persistent in the environment.

Phthalates are used as plasticizers in the manufacture of materials such as polyvinyl chloride, polypropylene, and polystyrene. Phthalates can accumulate in sediment particles and bioaccumulate in the lipid reservoirs of organisms. Laboratory contamination during the analysis of phthalates has been documented in the past (Lopes and Furlong, 2001) because of the widespread use of plastics in modern laboratories. Some phthalates are suspected carcinogens.

Background, Purpose, and Scope

Salem is the capital of Oregon, as well as its third largest city, with a population of 131,385 in 2000 (Portland State University, 2001). Salem is located centrally in the Willamette Valley, a fertile and agriculturally productive region. Land use in the Salem area is diverse, including large amounts of urban, industrial, residential, and agricultural activities that can impact surface-water quality.

Water quality is important because Salem-area streams support salmonid fish rearing and spawning, resident fish and aquatic life, water contact recreation, aesthetic quality, and water supply. The following three creeks in the study area were listed in 1998 by the Oregon Department of Environmental Quality as being water-quality limited: Mill Creek (for fecal-indicator bacteria and temperature), Clark Creek (for bacteria) and Pringle Creek (for dieldrin, an organochlorine insecticide, and for bacteria and temperature), (Oregon Department of Environmental Quality, 2001).

In 1999, the U.S. Geological Survey (USGS) entered into a cooperative agreement with the City of Salem, Oregon, to (1) assess the occurrence and concentrations of selected elements and organic chemicals in streambed sediments from the Salem area, (2) compare Salem-area concentrations to published screening values for the protection of aquatic life, (3) compare Salem-area concentrations to those in streambed sediments in the Willamette Basin and nationwide, and

(4) identify contaminant patterns that would help managers make decisions regarding future activities in monitoring and pollution control. This report contains data and interpretations concerning elements and organic chemicals from 16 streambed sediment samples that were collected from 14 sites on small streams in the Salem area during October 6-20, 1999 (low-flow conditions). Additionally, land use data were gathered from several sources to produce a geographic information system (GIS) coverage to compute the land use percentages for the contributing drainage area for each site.

Acknowledgments

The author acknowledges the City of Salem Public Works Department for cooperative funding and Jeanne Miller, City of Salem, for logistical assistance. Frank Rinella (USGS) oriented the field group on streambed sediment studies and gave instruction on sampling techniques, as well as helping interpret the results. Steve Rodgers (USGScontractor), and Jim Gengler and Bill Fear (both of the City of Salem) collected and processed the streambed sediment samples. Bernie Bonn (Clean Water Services, Hillsboro, Oregon, and formerly of the USGS) gave input for preparation of this report. Tana Haluska (USGS) did the GIS work, and Ken Skach (USGS) produced the graphics.

STUDY DESIGN AND METHODS

Fourteen sites on streams draining into the Willamette River and its tributaries in the Salem area were sampled for streambed sediments (fig. 1). Data from several sources were compiled into a geographical information system (GIS) coverage for the study area. Land use and land cover data were obtained from:

1. City of Salem—Land use data for the area within the city limits of Salem.
2. Marion County—Zoning data from the county outside of Salem city limits.
3. Landsat data—Satellite data classified and interpreted for the areas outside of the City of Salem and Marion County, and north of latitude 44.819 decimal degrees.
4. USGS National Land Use Data—Land use data for the areas outside of the City of Salem and Marion County, and south of latitude 44.819 decimal degrees.

Each site is influenced by an upstream drainage basin having a different mix of land use categories (table 1). Land use upstream from the sites at Claggett Creek, Clark Creek, Pringle Creek, and East Fork of Pringle Creek is at least 87% urban. The land use of the contributing basins of the four Mill Creek sites is predominantly agricultural (at least 72%). The drainage basin of Gibson Creek is composed mostly of agricultural, grassland, and forestland uses. It was not possible to determine the contributing drainage area of Shelton Ditch because part of the flow in Shelton Ditch is diverted from Mill Creek.

Table 1. Sampling site summary and land use, Salem area, Oregon, 1999
[Map ID (identification) refers to the number on figure 1; --, not calculable; RM, river mile]

Map ID	Site name	Drainage area (square miles)	Land use (percent)		
			Urban	Agricultural	Grassland and forest
14	Battle Creek	10.6	57	43	0
3	Claggett Creek	7.0	100	0	0
8	Clark Creek	2.4	100	0	0
7	Croisan Creek	4.8	53	47	0
12	East Fork of Pringle Creek	2.7	87	13	0
1	Gibson Creek	5.7	10	64	26
2	Glenn Creek	4.1	45	44	11
4	Mill Creek near mouth	112.5	26	72	2
10	Mill Creek upstream from Mill Race (RM 2.2)	110.6	25	73	2
11	Mill Creek upstream from Shelton Ditch (RM 3.4)	109.5	24	74	2
13	Mill Creek at Kuebler Road (RM 6.4)	105.4	22	76	2
6	Pettyjohn Creek	1.7	49	51	0
9	Pringle Creek	8.8	96	4	0
5	Shelton Ditch	--	--	--	--

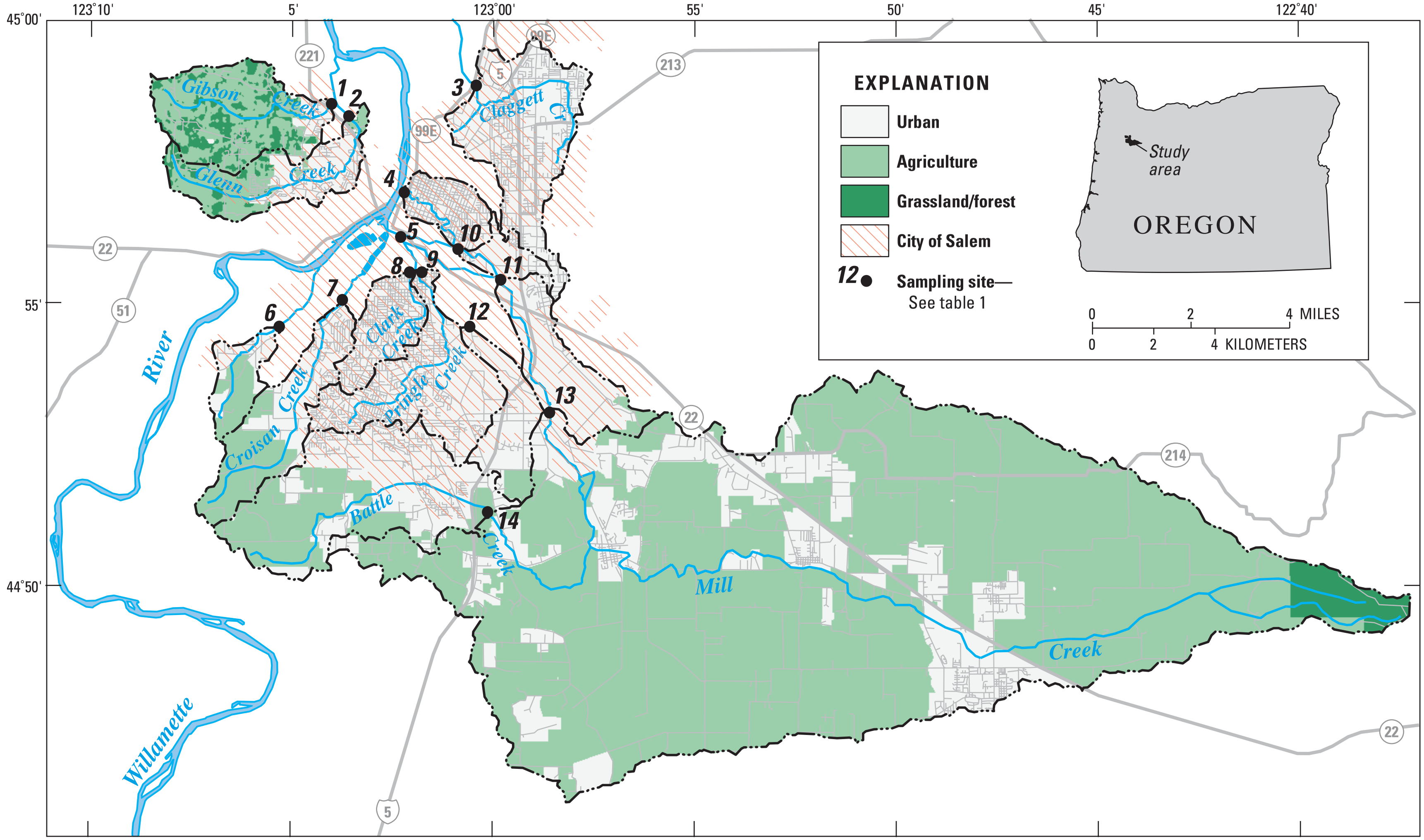

Figure 1. Streambed sediment sampling site locations and land use, Salem area, Oregon.

Sample Collection and Processing

Streambed sediment samples were collected from several depositional areas at each site using procedures described in detail by Shelton and Capel (1994). The top 1–2 cm of fine-grained sediment was collected with a Teflon scoop until about 8 liters of wet sediment was obtained. The subsamples for elemental analysis were sieved through a 63-µm nylon screen, and the sediment was placed in polyethylene containers. The subsamples for the analysis of organic chemicals were sieved through a 2-mm stainless-steel sieve and stored in glass containers. Due to program constraints, the samples, which were collected in October 1999, were not submitted for analysis until July 2000. Samples for organic analysis were stored in a freezer in accordance with procedures outlined by the USGS National Water-Quality Laboratory (William R. White, USGS, written commun., 1999) and samples for elemental analysis were air dried and stored at room temperature until analysis as recommended by the USGS Geologic Discipline Laboratory (Rick Sanzolone, USGS, written commun., 1999).

Chemical Analyses

Streambed sediment samples were analyzed for major and trace elements by the USGS Geologic Discipline Laboratory in Lakewood, Colorado. Organochlorine pesticides, pesticide metabolites, PCBs, semivolatile organic compounds, and organic carbon content were analyzed at the USGS National Water-Quality Laboratory in Lakewood, Colorado. The sediment size fraction less than 63 µm was analyzed by the USGS Cascades Volcano Observatory in Vancouver, Washington. The analytical methods are summarized in table 2.

Each analytical method used for quantifying an element or organic chemical in streambed sediment has a specific manner in which the solid material was extracted to produce a liquid which was in turn analyzed. A total chemical extraction uses strong acids to completely dissociate the sediment, whereas another approach is to use soft extraction techniques that are operationally defined.

Different designations were used by the laboratories to indicate minimum levels of detection for the different methods. A minimum reporting level (MRL) was used for elements, organochlorine pesticides, and PCBs. If a concentration was measured by the laboratory as being less than the MRL or if the concentration was too small to quantify, the value was reported as a nondetection. A method detection limit (MDL) was used for semivolatile compounds, such as PAHs, phthalates, and phenols. Concentrations less than the MDL may be reported.

The laboratory used an “E” remark code to identify an estimated concentration. This code was used when the identification of a compound was qualitatively confirmed, but the concentration was estimated because there was greater uncertainty about the measurement for one of the following reasons:

- The calculated concentration was less than 2xMDL.
- The calculated concentration was less than the lowest calibration standard.
- The calculated concentration was greater than the highest calibration standard.
- The concentration was uncertain because of a matrix interference.
- The concentration was uncertain because the compound was detected in instrument blanks.

The laboratory used an “M” remark code for some organic chemicals to indicate a compound that was identified at a low concentration that would round to zero. An unquantified result of “M” is preferable to reporting a low concentration value whose uncertainty is known to be high. Similarly, reporting “M” is preferable to reporting a value of zero, which could be inferred to mean “not present” when the analysis indicated that the compound was present.

Quality Assurance

To ensure the accuracy and precision of the analysis of the streambed sediment samples, two samples were split and analyzed. These two quality-assurance samples, collected at Pringle Creek and Clark Creek, represent 14% of the sites sampled. At those sites, the composited samples were sieved as usual, and then the sieved material was split, or subsampled. This type of a split sample gives an indication of the variability due to sample preparation and analysis, but it does not address the variability due to sample

Table 2. Elements and compounds analyzed in streambed sediment samples, Salem area, Oregon, 1999

[USGS, U.S. Geological Survey; letters identify the analytical method (see footnotes); CAS, Chemical Abstracts Service registry number; --, no CAS number exists for the given analyte. This table was modified from Bonn, 1999, p. 6–7]

Analyte name(s)	Method	USGS parameter code	CAS
Major elements			
aluminum (Al)	a	34790	7429–90–5
calcium (Ca)	a	34830	7440–70–2
iron (Fe)	a	34880	7439–89–6
magnesium (Mg)	a	34900	7439–95–4
phosphorus (P)	a	34935	7723–14–0
potassium (K)	a	34940	7440–09–7
sodium (Na)	a	34960	7440–23–5
sulfur (S)	b	34970	7704–34–9
titanium (Ti)	a	49274	7440–32–6
Minor elements			
antimony (Sb)	c	34795	7440–36–0
arsenic (As)	c	34800	7440–38–2
barium (Ba)	a	34805	7440–39–3
beryllium (Be)	a	34810	7440–41–7
bismuth (Bi)	a	34816	7440–69–9
cadmium (Cd)	d	34825	7440–43–9
cerium (Ce)	a	34835	7440–45–1
chromium (Cr)	a	34840	7440–47–3
cobalt (Co)	a	34845	7440–48–4
copper (Cu)	a	34850	7440–50–8
europium (Eu)	a	34855	7440–53–1
gallium (Ga)	a	34860	7440–53–3
gold (Au)	a	34870	7440–57–5
holmium (Ho)	a	34875	7440–60–0
lanthanum (La)	a	34885	7439–91–0
lead (Pb)	a	34890	7439–92–1
lithium (Li)	a	34895	7439–93–2
manganese (Mn)	a	34905	7439–96–5
mercury (Hg)	e	34910	7439–96–5
molybdenum (Mo)	a	34915	7439–98–7
neodymium (Nd)	a	34920	7440–00–8
nickel (Ni)	a	34925	7440–02–0
niobium (Nb)	a	34930	7440–03–1
scandium (Sc)	a	34945	7440–20–2
selenium (Se)	c	34950	7782–49–2
silver (Ag)	d	34955	7440–22–4
strontium (Sr)	a	34965	7440–24–6
tantalum (Ta)	a	34975	7440–25–7
thorium (Th)	f	34980	7440–29–1
tin (Sn)	a	34985	7440–31–5
uranium (U)	f	35000	7440–61–1
vanadium (V)	a	35005	7440–62–2
ytterbium (Yb)	a	35015	7440–64–4
yttrium (Y)	a	35010	7440–65–5
zinc (Zn)	a	35020	7440–66–6

Table 2. Elements and compounds analyzed in streambed sediment samples, Salem area, Oregon, 1999—Continued

[USGS, U.S. Geological Survey; letters identify the analytical method (see footnotes); CAS, Chemical Abstracts Service registry number; --, no CAS number exists for the given analyte. This table was modified from Bonn, 1999, p. 6–7]

Analyte name(s)	Method	USGS parameter code	CAS
Organochlorine pesticides			
aldrin	g	49319	309–00–2
cis-chlordane	g	49320	5103–71–9
trans-chlordane	g	49321	5103–74–2
chlorneb (Demosan, Soil fungicide 1823)	g	49322	2675–77–6
dacthal (DCPA, chlorthaldimethyl)	g	49324	1862–32–1
o,p'-DDD (*o,p'*-DDT metabolite)	g	49325	53–19–0
p,p'-DDD (*p,p'*-DDT metabolite)	g	49326	72–54–8
o,p'-DDE (*p,p'*-DDT metabolite)	g	49327	3424–82–6
p,p'-DDE (*o,p'*-DDT metabolite)	g	49328	72–55–9
o,p'-DDT	g	49329	789–02–6
p,p'-DDT	g	49330	50–29–3
dieldrin	g	49331	60–57–1
endosulfan I (α-endosulfan, Thiodan)	g	49332	959–98–8
endrin	g	49335	72–20–8
α-HCH (α-Lindane, *alpha*-hexachlorocylohexane, α-BHC)	g	49338	319–84–6
β-HCH (*beta*-hexachlor-cylohexane, β-BHC)	g	49339	319–85–7
γ-HCH (Lindane, *gamma*-hexachlorocylohexane, γ-BHC)	g	49345	58–89–9
heptachlor (Velsicol 104)	g	49341	76–44–8
heptachlor epoxide (heptachlor metabolite)	g	49342	1024–57–3
isodrin (Compound 711)	g	49344	465–73–6
o,p'-methoxychlor	g	49347	30667–99–3
p,p'-methoxychlor (Marlate)	g	49346	72–43–5
mirex (dechlorane)	g	49348	2385–85–5
cis-nonachlor	g	49316	5103–73–1
trans-nonachlor	g	49317	39765–80–5
oxychlordane	g	49318	27304–13–8
cis-permethrin (Ambush, Astro, Pounce, Pramex, Pertox, Ambush-Fog, Kafil, Perthrine, Picket, Picket-G, Dragnet, Talcord, Outflank, Stockade, Elsmin, Coopex, Peregin, Stomoxin, Stomoxin P, Qamlin, Corsair, Tornade)	g	49349	61949–76–6
trans-permethrin (same trade names as for *cis*-permethrin)	g	49350	61949–77–7
toxaphene	g	49351	8001–35–2
PAHs (polycyclic aromatic hydrocarbons)			
acenaphthene	h	49429	83–32–9
acenaphthylene	h	49428	208–96–8
anthracene	h	49434	120–12–7
benz[*a*]anthracene	h	49436	56–55–3

Table 2. Elements and compounds analyzed in streambed sediment samples, Salem area, Oregon, 1999—Continued

[USGS, U.S. Geological Survey; letters identify the analytical method (see footnotes); CAS, Chemical Abstracts Service registry number; --, no CAS number exists for the given analyte. This table was modified from Bonn, 1999, p. 6–7]

Analyte name(s)	Method	USGS parameter code	CAS
PAHs (polycyclic aromatic hydrocarbons)—Continued			
benzo[*a*]pyrene	h	49389	50–32–8
benzo[*b*]fluoranthene	h	49458	205–99–2
benzo[*ghi*]perylene	h	49408	191–24–2
benzo[*k*]fluoranthene	h	49397	207–08–9
chrysene	h	49450	218–01–9
dibenz[*a,h*]anthracene	h	49461	53–70–3
fluoranthene	h	49466	206–44–0
9H-fluorene	h	49399	86–73–7
indeno[1,2,3-*cd*]pyrene	h	49390	193–39–5
naphthalene	h	49402	91–20–3
phenanthrene	h	49409	85–01–8
pyrene	h	49387	129–00–0
Alkyl-PAHs			
1,2-dimethylnaphthalene	h	49403	573–98–8
1,6-dimethylnaphthalene	h	49404	575–43–9
2,6-dimethylnaphthalene	h	49406	581–42–0
2-ethylnaphthalene	h	49948	939–27–5
1-methyl-9H-fluorene	h	49398	1730–37–6
1-methylphenanthrene	h	49410	832–69–9
1-methylpyrene	h	49388	2381–21–7
2-methylanthracene	h	49435	613–12–7
4,5-methylenephenanthrene	h	49411	203–64–5
2,3,6-trimethylnaphthalene	h	49405	829–26–5
Azaarines			
acridine	h	49430	260–94–6
benzo[*c*]cinnoline	h	49468	230–17–1
2,2'-biquinoline	h	49391	119–91–5
9H-carbazole	h	49449	86–74–8
isoquinoline	h	49394	119–65–3
phenanthridine	h	49393	229–87–8
quinoline	h	49392	91–22–5
Phthalates			
bis(2-ethylhexyl)phthalate	h	49426	117–81–7
butylbenzylphthalate	h	49427	85–68–7
diethylphthalate	h	49383	84–66–2
dimethylphthalate	h	49384	131–11–3
di-*n*-butylphthalate	h	49381	84–74–2
di-*n*-octylphthalate	h	49382	117–84–0
Phenols			
C8-alkylphenol	h	49424	--
2-chlorophenol	h	49467	95–57–8
4-chloro-3-methylphenol	h	49422	59–50–7
p-cresol	h	49451	106–44–5
3,5-dimethylphenol	h	49421	108–68–9
phenol	h	49413	108–95–2

Table 2. Elements and compounds analyzed in streambed sediment samples, Salem area, Oregon, 1999—Continued

[USGS, U.S. Geological Survey; letters identify the analytical method (see footnotes); CAS, Chemical Abstracts Service registry number; --, no CAS number exists for the given analyte. This table was modified from Bonn, 1999, p. 6–7]

Analyte name(s)	Method	USGS parameter code	CAS
Chlorinated aromatic compounds			
2-chloronaphthalene	h	49407	91–58–7
1,2-dichlorobenzene	h	49439	95–50–1
1,3-dichlorobenzene	h	49441	541–73–1
1,4-dichlorobenzene	h	49442	106–46–7
hexachlorobenzene	g	49343	118–74–1
pentachloroanisole	g	49460	1827–21–4
pentachloronitrobenzene	h	49446	82–68–5
polychlorinated biphenyls (total-PCB)	g	49459	--
1,2,4-trichlorobenzene	h	49438	120–82–1
Other			
anthraquinone	h	49437	84–65–1
azobenzene	h	49443	103–33–3
bis(2-chloroethoxy)methane	h	49401	111–91–1
4-bromophenyl-phenylether	h	49454	101–55–3
4-chlorophenyl-phenylether	h	49455	7005–72–3
dibenzothiophene	h	49452	132–65–0
2,4-dinitrotoluene	h	49395	121–14–2
isophorone	h	49400	78–79–1
nitrobenzene	h	49444	98–95–3
N-nitrosodiphenylamine	h	49433	86–30–6
N-nitrosodi-*n*-propylamine	h	49431	621–64–7

[a]Homogenized bed sediment was digested using a mixture of hydrochloric, nitric, perchloric and hydrofluoric acids at low temperature. The resulting solution was evaporated to dryness, dissolved in aqua regia, and analyzed by ICP-AES (inductively coupled plasma/atomic emission spectrometry) (Briggs, 1990).

[b]Homogenized bed sediment was analyzed by combustion with infrared absorption detection using an automated sulfur analyzer (Curry, 1990).

[c]Homogenized bed sediment was digested using a mixture of nitric, perchloric and hydrofluoric acids at 105–110°C (degrees Celsius). The resulting solution was analyzed by HG-AAS (hydride generation atomic absorption spectrophotometry) (Welsch and others, 1990).

[d]Homogenized bed sediment was digested with hydrofluoric acid, hydrochloric acid, and hydrogen peroxide. The resulting solution was extracted into an organic phase which was analyzed using FAA (flame atomic absorption spectrometry (O'Leary and Viets, 1986).

[e]Homogenized bed sediment was digested using nitric acid and sodium dichromate. Mercury in the digest was reduced to elemental form and analyzed by continuous-flow CV-AAS (cold-vapor atomic absorption spectrophotometry) (O'Leary and others, 1990).

[f]Homogenized bed sediment was irradiated with neutrons. Delayed neutrons from the sample were counted (McKown and Knight, 1990).

[g]Homogenized bed sediment was Soxhlet extracted. Gel permeation chromatography was used to remove inorganic sulfur and large natural molecules. The extract was fractionated using alumina/silica adsorption. The extracts were analyzed by GC-ECD (gas chromatography with electron capture detection) (Foreman and others, 1995).

[h]Homogenized bed sediment was Soxhlet extracted. Gel permeation chromatography was used to remove inorganic sulfur and large natural molecules. The extract was analyzed by GC-MS (gas chromatography with mass spectrometry) (Furlong and others, 1996).

collection techniques or spatial location within a reach. The relative percent difference (RPD) between the sample splits was calculated as:

$$\frac{|\text{concentration in one subsample} - \text{concentration in other subsample}|}{(\text{concentration in one subsample} + \text{concentration in other subsample})/2} \times 100.$$

Results of the split sample analyses are shown in Appendix B. Of the 45 elements analyzed, 7 had a RPD for the split of more than 10% (table 3). Many of these instances were when concentrations were near the detection limits and therefore variability of the measurement would be expected to be larger. Relative percent differences were also calculated for the 97 organic chemicals analyzed for in the split samples; relative differences larger than 20 percent are shown in table 4. RPDs were not calculated for concentrations that were designated as estimated ("E") by the laboratory. The organic chemical with the largest relative percent difference for the split sample was p-cresol, which was reported as 1,400 µg/kg (micrograms per kilogram) in the first sample, and as 660 µg/kg in the split sample (Appendix B).

As a check of the accuracy of the analytical methods for organochlorine pesticides and semivolatile compounds, the liquid extract from each environmental sample was "spiked" at the laboratory with several surrogate compounds prior to analysis. These compounds, which are often deuterated (labelled with deuterium, or "heavy hydrogen"), are not expected to be present in a natural environmental sample. The percent recovery of the surrogate compounds provides an indication of the overall method performance for that sample. The recoveries of these surrogates are in table 5 under the heading "spiked environmental samples." The same surrogate organic compounds were analyzed in an aqueous test solution that also contained known spikes of the analyte compounds. One test solution spike was done per set of samples, and the samples from the present study were from three different sample sets. These results are listed in table 5 under "spiked test solutions." Surrogate recoveries for streambed sediment samples in this study were acceptable and were comparable to typical laboratory performance, indicating that matrix interference probably was not a big factor in these analyses.

Laboratory blanks were also analyzed for each sample set. At one site, Glenn Creek, the laboratory blank for butylbenzylphthalate for the sample set indicated contamination larger than the reporting level (blank = 75.9 µg/kg).

Data Analysis

Comparisons to guidelines and other data

Evaluating the concentrations of elements and organic chemicals in streambed sediment involves comparing those concentrations to sediment quality guidelines (SQGs) developed by various groups for freshwater ecosystems. Guidelines are numerical limits recommended to support and maintain designated uses of the aquatic environment. Unlike standards (for drinking water, for example), guidelines are threshold values that have no legal enforcement or regulatory status. SQGs for streambed sediment can be used as a starting point for evaluating contaminants of concern and geographical areas of concern, and for evaluating the need for further studies into ecosystem health. Many different SQGs have been developed for streambed sediment (MacDonald and others, 2000). Each SQG is based on two components: a particular type of sample preparation and analysis (which may involve sieving, digesting, or extracting the sediment sample) and an evaluation of how measured exceedances of the SQG would affect freshwater ecosystems, which can involve field studies or laboratory studies like the Spiked-Sediment Toxicity Test (MacDonald and others, 1992). For the present study, SQGs were selected for each element and organic chemical based on the type of sample preparation and analysis used and for compatibility for comparisons to other data sets in the United States, especially the NAWQA program (U.S. Geological Survey, 1999). An attempt also was made to select guidelines that applied to many of the constituents that were analyzed.

SQGs for comparison to the Salem-area data were from the Puget Sound Dredged Disposal Analysis Program (2000) and from the Canadian Council of Ministers of the Environment (2001). SQGs for

Table 3. Relative percent differences of selected elements in split samples

Relative percent (%) difference was calculated as [|(concentration A - concentration B)|/ (concentration A + concentration B)/2] x 100%. Tabled values are those that exceeded 10%. Also given is the average of the two replicate concentrations. The majority of elements did not have a relative percent difference larger than 10% and, hence, were not included in this table; NE 10%, Relative percent difference did not exceed 10%; µg/g, micrograms per gram]

Site of replicate	Berylium	Cadmium	Chromium	Mercury	Nickel	Selenium	Tantalum	Tin
Pringle Creek	NE 10%	18.2% at 1.1 µg/g	51.2% at 100 µg/g	18.2% at 0.11 µg/g	32.9% at 40 µg/g	NE 10%	66.7% at 2 µg/g	NE 10%
Clark Creek	23.5% at 1.7 mg/g	NE 10%	NE 10%	13.3% at 0.22 µg/g	NE 10%	22.2% at 0.4 µg/g	NE 10%	15.4% at 6 µg/g

Table 4. Relative percent differences of selected organic chemicals in split samples

[Relative percent difference was calculated as [|(concentration A - concentrationB)|/ (concentration A + concentration B)/2] x 100%. Tabled values are those that exceeded 20%. Also given is the average of the two replicate concentrations. The majority of organic chemicals did not have a relative percent difference larger than 20%, and were hence not included in this table. Concentrations that were designated as estimated by the laboratory were not included in this table. NE 20%, relative percent difference did not exceed 20%; µg/kg, micrograms per kilogram]

Site of replicate	Benz[a]-anthracene	Hexachloro-benzene	Benzo[a]-pyrene	Benzo[k]-fluoranthene	Chrysene	Fluoranthene	p,p′-DDT	p-cresol	Phenanthrene	Pyrene
Pringle Creek	25.0% at 160 µg/kg	54.6% at 6 µg/kg	NE 20%	NE 20%	22.2% at 320 µg/kg	36.6% at 470 µg/kg	22.2% at 4 µg/kg	NE 20%	23.3%at 220 µg/kg	39.0% at 380 µg/kg
Clark Creek	27.9% at 820 µg/kg	NE 20%	30.8% at 1,000 µg/kg	40.0% at 1,200 µg/kg	22.2% at 1,400 µg/kg	26.1% at 2,300 µg/kg	NE 20%	71.8% at 1,000 µg/kg	42.9% at 1,400 µg/kg	27.3% at 2,200 µg/kg

Table 5. Comparison of surrogate recoveries for spiked environmental samples and spiked test solutions

[Means, standard deviations, and ranges all in units of percent recovery; N is the number of samples]

	Spiked environmental samples				Spiked test solutions			
Compound	Mean	Standard deviation	Range	N	Mean	Standard deviation	Range	N
GC-ECD Method—Sediment (for organochlorine pesticides and total PCB [polychlorinated biphenyls])								
α-HCH-d_6	70	16	54–96	14	59	6	52–63	3
GC-MS Method—Sediment (for semivolatile organic compounds such as PAHs [polycyclic aromatic hydrocarbons], phthalates, and phenols)								
2-fluorobiphenyl	58	8	46–68	14	64	3	61–67	3
nitrobenzene-d_5	59	13	44–84	14	63	6	56–67	3
terphenyl-d_{14}	85	9	66–98	14	83	6	78–91	3

elements are shown in table 6 and SQGs for organic chemicals are shown in table 7. The Puget Sound Dredged Disposal Analysis Program (PSDDA) is a joint program of the U.S. Environmental Protection Agency (USEPA) and the U.S. Army Corps of Engineers, with the responsibility of regulating dredged material management activities in the State of Washington under the Clean Water Act. The PSDDA guidelines were promulgated by Region 10 of the USEPA (which includes Oregon), and the guidelines may be applicable to Salem-area streams in the event that a streambed-sediment cleanup is carried out (John Malek, USEPA Region 10, oral commun., 2002). Two PSDDA guidelines are listed for elements and organic chemicals, the screening level (SL) and the maximum level (ML), (tables 6 and 7).

Table 6. Guidelines for elements in streambed sediments
[Sediment screening values from PSDDA Guidelines (Puget Sound Dredged Disposal Analysis Program, 2000) and Canadian Interim Guidelines (Canadian Council of Ministers of the Environment, 2001); -- indicates that no guideline exist; µg/g, micrograms per gram dry weight]

		PSDDA Guideline		
Element	Laboratory minimum reporting level (µg/g)	Screening level (µg/g)	Maximum level (µg/g)	Canadian Interim Guideline probable effects level (µg/g)
antimony	0.1	150	200	--
arsenic	.1	57	700	17.0
cadmium	.1	5.1	14	3.5
chromium	1	--	--	90.0
copper	1	390	1,300	197
lead	4	450	1,200	91.3
mercury	.02	.41	2.3	.486
nickel	2	140	370	--
silver	.1	6.1	8.4	--
zinc	4	410	3,800	315

The smaller value is the SL, and it identifies the concentration below which the disposal of dredged material is expected to have no unacceptable adverse effects, and therefore further biological testing of the dredged material would not be required for unconfined, open-water disposal (PSDDA, 2000). The larger guideline value is the maximum level (ML). If one or more chemicals have concentrations between the SL and the ML, standard biological testing would be required to determine the suitability of the material for disposal. Biological testing involves bioassays using several species of benthic invertebrates (PSDDA, 2000). If a single chemical has a concentration between the ML and twice the ML, biological testing is needed. Finally, if a single chemical exceeds twice the ML, there is reason to believe that the dredged material would be unacceptable for disposal.

Canadian governmental agencies have based sediment guidelines on the simultaneous effects of several contaminants on benthic organisms (Persaud and others, 1993). The probable effect level (PEL), an interim guideline developed by the Canadian Council of Ministers of the Environment (CCME) (2001), is the concentration above which adverse biological effects are expected to occur frequently (tables 6 and 7). In other words, if the PEL is exceeded, it is probable that aquatic life has been negatively affected. The PELs were developed based on the total analytical digestion of streambed sediment, which was the method used in the present study. However, the PELs were based on the analysis of an unsieved sediment sample, whereas the Salem-area samples for elements were sieved, and only the sediments finer than 63 micrometers in diameter (wherein element concentrations tend to be larger) were analyzed. Therefore, comparisons of the Salem samples to the Canadian PELs for elements may overestimate the adverse effects on aquatic life, which is a more conservative position. However, if most of the sediment at a site was finer than 63 micrometers, then the Canadian PEL would be applied appropriately.

Like the PSDDA guidelines, the CCME PELs were based on a series of biological tests on benthic organisms (Canadian Council of Ministers of the Environment, 2001). The PELs are considered to be widely applicable to streambed sediment samples because they were developed from tests of actual sediment samples with varying chemical matrices and particle size compositions. Sediments with constituent concentrations larger than the PEL are considered to represent significant hazards to aquatic organisms, and followup biological assessment is recommended according to the CCME. The biological testing or assessment mentioned by the PSDDA and the CCME guidelines involve various techniques, including spiked-sediment bioassays, whole-sediment bioassays, and toxicological tests with specific aquatic invertebrates. Tests using algae or bacteria have also been developed to evaluate the resuspension of chemicals into the water column.

Table 7. Guidelines for organic chemicals in streambed sediments

[Sediment screening values from PSDDA Guidelines (Puget Sound Dredged Disposal Analysis Program, 2000) and Canadian Interim Guidelines (Canadian Council of Ministers of the Environment, 2001); -- indicates that no guideline exists; µg/kg, microgram per kilogram dry weight]

Organic chemical	PSDDA Guideline		Canadian Interim Guideline probable effects level (µg/kg)
	Screening level (µg/kg)	Maximum level (µg/kg)	
Organochlorine pesticides			
total chlordane[a]	--	--	8.87
dieldrin	10	--	6.67
Total DDD[b]	--	--	8.51
Total DDE[c]	--	--	6.75
Total DDT[d]	6.9	69	--
endrin	--	--	62.4
γ-HCH (lindane)	10	--	1.38
heptachlor	10	--	--
heptachlor epoxide	--	--	2.74
Polycyclic aromatic hydrocarbons (PAHs)			
acenaphthene	500	2,000	--
acenaphthylene	560	1,300	--
anthracene	960	13,000	--
benz[*a*]anthracene	1,300	5,100	385
benzo[*a*]pyrene	1,600	3,600	782
chrysene	1,400	21,000	862
dibenz[*a,h*]anthracene	230	1,900	--
fluoranthene	1,700	30,000	2,355
naphthalene	2,100	2,400	--
phenanthrene	1,500	21,000	515
pyrene	2,600	16,000	875
Phthalates			
bis(2-ethylhexyl)phthalate	8,300	--	--
butylbenzylphthalate	970	--	--
diethylphthalate	1,200	--	--
dimethylphthalate	1,400	--	--
di-*n*-butylphthalate	5,100	--	--
di-*n*-octylphthalate	6,200	--	--
Phenols			
p-cresol	670	3,600	--
phenol	420	1,200	--

[a] Total chlordane is the sum of *cis*-chlordane, *trans*-chlordane, *cis*-nonachlor, *trans*-nonachlor, and oxychlordane.

[b]Total DDD is the sum of *o,p*'-DDD and *p,p*'-DDD.

[c]Total DDE is the sum of *o,p*'-DDE and *p,p*'-DDE.

[d] Total DDT is the sum of *p,p*'-DDD, *p,p*'-DDE, and *p,p*'-DDT.

The concentrations of elements and organic chemicals measured in the Salem area were compared to values reported for the Willamette Basin and also to a nationwide data set. The Willamette data were collected by the USGS National Water-Quality Assessment Program (NAWQA) between 1992 and 1995 (Wentz and others, 1998a). The national distribution contains NAWQA data collected from 52 large river basins (including the Willamette Basin) between 1992 and 1997 (U.S. Geological Survey, 2002). The sample collection and processing methods used in the Salem area study were the same as those used by the NAWQA program. Therefore, comparisons among these three data sets should not be affected by differences in sampling, processing, or analytical methods.

Statistical and Graphical Methods

Nonparametric statistics were used in this report. Such procedures are useful when data are not normally distributed, which is a common occurrence with water-quality data. Pairwise correlations were performed among concentrations of elements and organic chemicals, and land use percentages using the Spearman rank technique. The hypothesis of these correlations was that the concentration of a constituent may be related to the percentage of a category of land use in the drainage basin upstream of a particular sampling site. For instance, sites with high percentages of urban land use might be expected to have higher concentrations of certain constituents related to anthropogenic effects.

The correlations were two-sided, that is, there was no expectation of a positive or negative correlation, and the alternative hypothesis was that Spearman's rho was not equal to zero. For the correlations, values of 0.5 times the detection limit (MRL or MDL) were substituted for nondetections. In cases where there were nondetections at a concentration larger than the usual detection limit, a value of 0.5 times the usual, lower detection limit was used. Estimated values were not treated differently from other values in the statistical analyses.

For graphical presentations in this report, estimated values were treated the same as values that were not estimated, but nondetections were not represented on the graph. For graphical presentations, and for testing for the exceedance of screening values, the nonrounded values were used, even though the rounded values are reported in the data tables in this report. For "M" coded values that would have rounded to zero, the nonrounded value was used.

RESULTS

Elements in Streambed Sediment

Summary statistics for concentrations of elements in streambed sediment are given in table 8. Several elements—antimony, cadmium, cobalt, copper, lead, manganese, mercury, nickel, selenium, silver, and zinc—can be considered to be enriched, because their concentrations were larger than established break-point concentrations (table 8). These break-points were based on discontinuities in the normal probability plots of elements in streambed sediment in the Willamette River Basin (Rinella, 1998). Break-points for elements indicate the boundary between two statistical populations—lower concentrations that can be considered not enriched and larger concentrations that can be considered to be enriched. Since the elements are naturally occurring, the finding of enrichment by this method does not distinguish between effects due to enriched geological sources and anthropogenic effects. At 8 of the 14 sites, lead concentrations were larger than the break-point concentration. Concentrations of cadmium and lead for the sample from Clark Creek were 5 times larger than the respective break-points.

Sediment quality guidelines were exceeded for two elements: lead and zinc (table 9). Zinc concentrations in the sample from Clark Creek exceeded both the PSDDA screening level guideline and the Canadian interim PEL guideline. The drainage basins above Clark Creek and Claggett Creek are 100 percent urban land use, and both sites had exceedances of guidelines for lead and zinc. The urban land use category includes industrial uses, so this is consistent with the findings of a previous study, in which large concentrations of lead and zinc in streambed sediment were associated with industrial areas (Forstner and Wittmann, 1979).

The concentrations of several elements were positively correlated with the percentage of a given land use in the drainage basin upstream from the sampling site. The basin percentage of urban land use was correlated positively (probability value less than 0.05) with: antimony, cadmium, chromium, copper, lead, magnesium, mercury, molybdenum, nickel, phosphorus, silver, sulfur, and zinc (table 10). These correlations probably are due to the anthropogenic activities affecting the air and water quality in urban areas.

Trace element concentrations in Salem-area streambed sediments were similar to those found in Willamette Basin streambed sediment and nationally (fig. 2). However, cadmium, lead, and zinc concentrations were larger in the sample from Clark Creek than for largest value for Willamette Basin data. This fact is probably due to the presence of predominately urban land use in the Clark Creek area.

Organic Chemicals in Streambed Sediment

Several organochlorine compounds were detected in Salem area streambed sediments (table 11). When organochlorines were detected, concentrations generally were similar to those measured elsewhere in the Willamette Basin and the Nation (fig. 3). The only

Table 8. Summary statistics for element concentrations in streambed sediment samples, Salem area, Oregon, 1999

[Concentrations of major elements in milligrams per gram (mg/g); minor elements in micrograms per gram (μg/g); all concentrations are expressed on a dry weight basis and are given one or two significant digits. Break-point concentrations are based on Rinella, 1998. The following elements were not detected in streambed sediment samples: bismuth, gold, and thallium]

Element	Minimum	25th percentile	Median	75th percentile	Maximum	Willamette River Basin break-point concentration (if available)	Number of samples exceeding break-point concentration
Major elements (mg/g)							
aluminum	72	79	80	83	100	--	--
calcium	5	11	12	13	16	--	--
iron	50	51	53	59	92	--	--
magnesium	3.2	6	6.5	6.8	8.5	--	--
phosphorus	1.1	1.3	1.5	1.6	1.9	--	--
potassium	4.1	7.3	9.0	11	14	--	--
sodium	3.2	8.8	9.0	10.0	12	--	--
sulfur	< .5	.6	.7	.8	1.3	--	--
titanium	6.8	8.6	9.2	9.9	18	--	--
Minor elements (μg/g)							
antimony	.6	.6	.6	1.1	2.2	1.3	2
arsenic	4.2	4.8	5.1	5.4	7.6	10	0
barium	420	420	540	600	670	--	--
beryllium	1.4	1.5	1.7	1.8	2.1	--	--
cadmium	.1	.2	.3	.6	3.2	.5	5
cerium	61	65	68	75	81		
chromium	66	71	73	76	88	100	0
cobalt	20	22	24	28	43	30	3
copper	31	40	45	56	93	50	5
europium	1.5	1.8	2.0	2.4	2.6	--	--
gallium	16	17	18	19	26	--	--
holmium	< 1	< 1	1	1	1	--	--
lanthanum	29	31	35	38	46	--	--
lead	21	28	38	84	160	30	8
lithium	21	24	25	26	26	--	--
manganese	900	1,200	1,400	1,800	2,900	1,400	6
mercury	.05	.05	.06	.12	.21	.11	5
molybdenum	.7	.8	.9	1.3	1.8	--	--
neodymium	30	31	36	42	48	--	--
nickel	23	28	30	32	46	30	7
niobium	13	14	16	18	24	--	--
scandium	19	22	23	24	39	--	--
selenium	.2	.3	.3	.4	.8	.35	6
silver	.2	.2	.2	.3	.4	.3	1
strontium	97	200	200	220	250	--	--
tantalum	1.2	1.2	1.4	1.5	2	--	--
thorium	6	6	7	8	9	--	--
tin	2.7	3.1	3.4	4.2	9.9	--	--
uranium	1.8	1.8	2.0	2.2	2.6	--	--
vanadium	160	170	180	200	360	--	--
yttrium	27	31	38	43	49	--	--
ytterbium	2.5	2.8	3.4	3.9	4.3	--	--
zinc	140	150	180	310	500	200	6

Table 9. Exceedances of streambed sediment guidelines, Salem area, Oregon, 1999

[Symbol meanings are as follows: ●, exceeds Puget Sound Dredged Disposal Analysis (PSDDA) Screening Level guideline (Puget Sound Dredged Disposal Analysis Program, 2000); •, exceeds Canadian Interim Probable Effects Level guideline (Canadian Council of Ministers of the Environment, 2001); --, indicates that there was no exceedance for the constituent at that site]

	Elements		Organochlorines					Polycyclic aromatic hydrocarbons and other compounds						
Site	lead	zinc	total chlordane[a]	dieldrin	Total DDD[b]	Total DDE[c]	Total DDT[d]	benz[*a*]anthracene	benzo[*a*]pyrene	chrysene	fluoranthene	phenanthrene	pyrene	*p*-cresol
Claggett Creek	•	•	•	--	--	--	●	--	--	--	--	--	--	--
Clark Creek	•	●•	•	•	--	--	●	•	•	•	●	•	•	●
East of Fork Pringle Creek	--	•	•	--	•	•	●[e]	--	--	--	--	--	--	--
Gibson Creek	--	--	--	--	--	•	●	--	--	--	--	--	--	--
Glenn Creek	--	--	--	--	•	•	●	--	--	--	--	--	--	--
Mill Creek near mouth	•	--	--	--	--	•	●	--	--	--	--	--	--	--
Mill Creek upstream from Shelton ditch	--	--	•	--	--	--	--	--	--	--	--	--	--	--
Pettyjohn Creek	--	--	•	--	--	•	●	--	--	--	--	--	--	●
Pringle Creek	--	•	•	--	•	•	●	--	--	--	--	--	--	--
Shelton Ditch	--	--	--	--	--	--	--	•	--	--	●	●•	•	--

[a]Total chlordane is the sum of *cis*-chlordane, *trans*-chlordane, *cis*-nonachlor, *trans*-nonachlor, and oxychlordane.
[b]Total DDD is the sum of *o,p*'-DDD and *p,p*'-DDD.
[c]Total DDE is the sum of *o,p*'-DDE and *p,p*'-DDE.
[d]Total DDT is the sum of *p,p*'-DDD, *p,p*'-DDE, and *p,p*'-DDT.
[e]Also exceeded the PSDDA maximum level guideline.

Note. For the following sites, no exceedances were observed: Battle Creek, Croisan Creek, Mill Creek upstream from Mill Race, and Mill Creek at Kuebler Road.

The following elements and compounds were detected in sediment at least once, but concentrations never exceeded PSDDA or CCME guidelines: antimony, arsenic, cadmium, chromium, copper, mercury, nickel, silver, acenaphthene, acenaphthylene, anthracene, benzo[*ghi*]perylene, dibenz[*a,h*]anthracene, 9H-fluorene, ideno[1,2,3-*cd*]pyrene, bis(2-ethylhexyl)phthalate, butylbenzylphthalate, diethylphthalate, dimethylphthalate, di-*n*-butylphthalate, di-*n*-octylphthalate, phenol, hexachlorobenzene, total PCB, and N-nitroso-diphenylamine.

The following compounds have PSDDA or CCME guidelines, and were not detected in sediment: endrin, γ-HCH (lindane), heptachlor, heptachlor epoxide, naphthalene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, and 1,2,4-trichlorobenzene.

exception was for total chlordane, which is the sum of *cis*- and *trans*-chlordane, *cis*- and *trans*-nonachlor, and oxychlordane. The concentration of total chlordane at Clark Creek was larger than in any sample from the Willamette Basin study. The Canadian interim PEL screening value for total chlordane was exceeded at six sites (table 9). Individual chlordanes (including *cis*- and *trans*-chlordane and *cis*- and *trans*-nonachlor, and oxychlordane) were detected at about 80% of the sites.

The most commonly detected organochlorine was *p,p'*-DDE, which was detected at all of the sites. This compound is a breakdown product (metabolite) of the insecticide DDT, which was banned from use in the United States in 1972. The fact that it was detected at each Salem-area site demonstrates the persistence of this family of compounds in the environment. Total DDT (the sum of *p,p'*-DDD, *p,p'*-DDE, and *p,p'*-DDT) concentrations exceeded the PSDDA screening level at eight sites, and exceeded twice the maximum level at the East Fork of Pringle Creek (fig. 3 and table 9).

None of the DDE, DDD, or DDT compounds were correlated with the percentage of any particular land use. At some locations in the Salem area, the land use has changed from agricultural to urban, so it is

Table 10. Elements and organic chemicals with concentrations positively correlated with the percentage of urban land use in the contributing basin

[The statistical test was the Spearman's rank test, at a probability level of 0.05 or less. There were no significant positive correlations with agricultural or grassland and forest land uses; PAHs, polycyclic aromatic hydrocarbons]

Elements	Organochlorine pesticides	PAHs	Alkyl-PAHs	Phthalates	Other
antimony	dieldrin	acenaphthylene	1-methylpyrene	butylbenzylphthalate	anthraquinone
cadmium		anthracene	4,5-methylenephenanthrene	diethylphthalate di-*n*-octylphthalate	dibenzothiophene total PCBs
chromium		benz[*a*]anthracene			
copper		benzo[*a*]pyrene			
lead		benzo[*b*]fluoranthene			
magnesium		benzo[*ghi*]perylene			
mercury		benzo[*k*]fluoranthene			
molybdenum		chrysene			
nickel		fluoranthene			
phosphorus		indeno[1,2,3-*cd*]pyrene			
silver		phenanthrene			
sulfur		pyrene			
zinc					

possible that organochlorine pesticides are associated now with land that was agricultural when these pesticides were in use. Concentrations of total DDE (*o,p'*-DDE plus *p,p'*-DDE) exceeded the Canadian interim PEL screening value at six sites (table 9). Dieldrin concentrations were positively correlated with percentage of urban land use (table 10), and the largest concentration was at Clark Creek, the only site that exceeded the Canadian Interim Guideline for dieldrin.

The most commonly detected semivolatile compounds were PAHs, alkyl-PAHs, phthalates, *p*-cresol, phenol, and anthraquinone (table 11). Several PAHs exceeded screening guidelines at Clark Creek and Shelton Ditch, and *p*-cresol exceeded guidelines at Clark Creek and Pettyjohn Creek (table 9). The largest phthalate concentrations in Salem-area streambed sediments generally were larger than the Willamette Basin maxima, but in the same range as national maxima (fig. 3).

The percentage of urban land use in the contributing drainage basin was positively correlated (Spearman's rho significant to the 0.05 probability level) with several organic chemicals (table 10). The fact that PAHs were associated with percentage urban land use is to be expected due to their origin from combustion sources, including automobiles. Some phthalates and total PCBs also were associated with percentage of urban land use; these constituents are products of industrial activities, which are often located in urban areas. Similar results were obtained in a recent nationwide study of organic compounds in streambed sediments (Lopes and Furlong, 2001), which found that PAHs and phthalates were associated with urban land use.

Implications for Future Monitoring and Site-Specific Findings

Of the 14 sites sampled, streambed sediment at the following 10 sites exceeded 1 or more of the CCME probable effects level guidelines (table 9): Claggett Creek, Clark Creek, East Fork of Pringle Creek, Gibson Creek, Glenn Creek, Mill Creek near mouth, Mill Creek upstream from Shelton Ditch, Pettyjohn Creek, Pringle Creek, and Shelton Ditch. According to the CCME, the recommended course of action is to carry out whole-sediment bioassays with benthic invertebrates at the 10 sites (Canadian Council of Ministers of the Environment, 1995).

For eight sites (Claggett Creek, Clark Creek, Gibson Creek, Glenn Creek, Mill Creek near mouth, Pettyjohn Creek, Pringle Creek, and Shelton Ditch), the

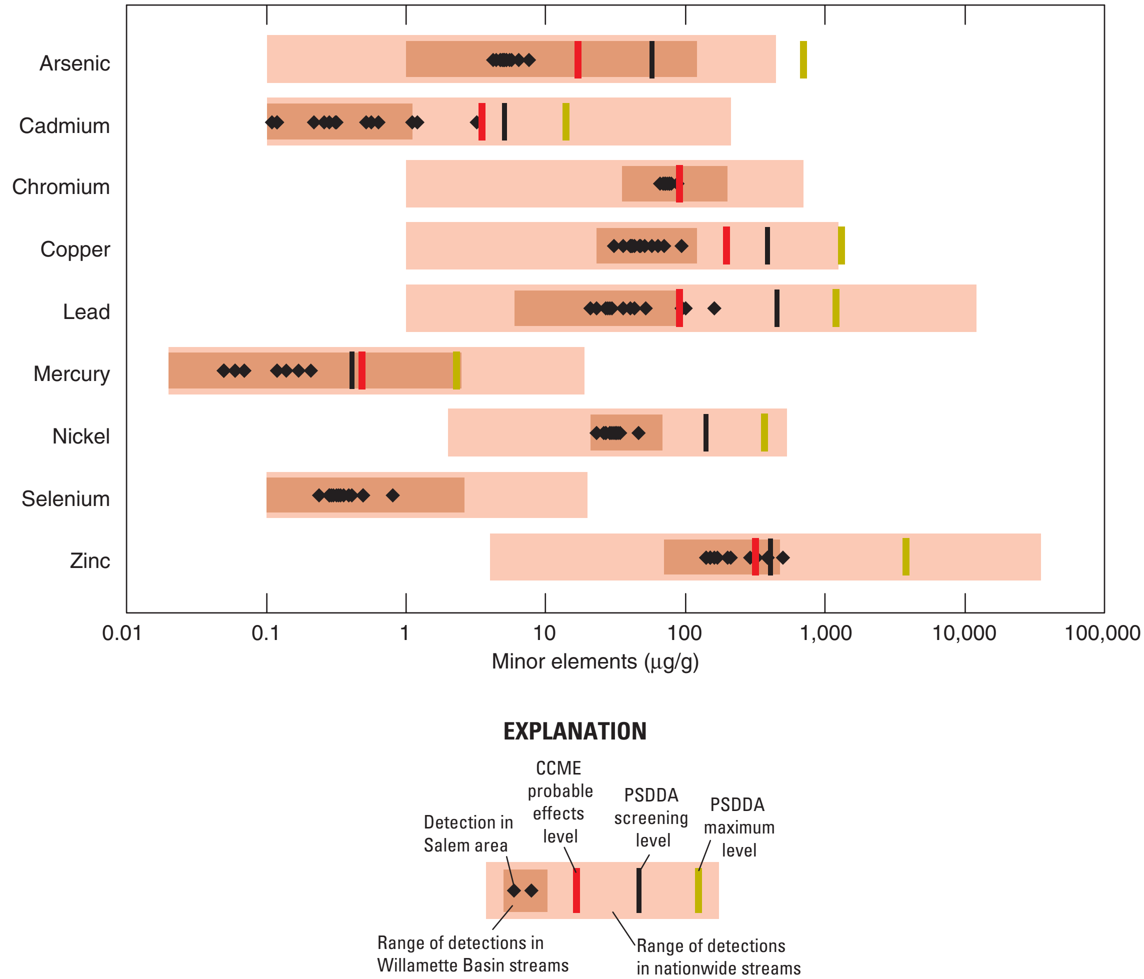

Figure 2. Comparison of concentrations of elements in streambed sediment samples from the Salem area with Willamette Basin concentrations, nationwide concentrations, and sediment quality guidelines [Willamette Basin data are from 1992 to 1995 (Wentz and others, 1998a), and nationwide data are from 1992 to 1997 (U.S. Geological Survey, 2002). Probable effects levels are from the Canadian Council of Ministers of the Environment, 2001; screening levels and maximum levels are from the Puget Sound Dredged Disposal Analysis Program, 2000. There are no sediment quality guidelines for selenium.]

PSDDA screening level was exceeded for one or more constituents. This means that bioassays would be required if the streambed sediment from these sites were considered as dredged material destined for open-water disposal (Puget Sound Dredged Disposal Analysis, 2000).

The concentration of total DDT (the sum of *p,p*'-DDD, *p,p*'-DDE, and *p,p*'-DDT) was 374 µg/kg at East Fork of Pringle Creek, and the PSDDA maximum level guideline is 69 µg/kg (Puget Sound Dredged Disposal Analysis, 2000). Because the concentration in the East Fork of Pringle Creek sample was more than twice the maximum level guideline, it would be considered unacceptable for disposal under PSDDA guidelines, if the material were to be dredged.

Data from this study indicate that there has been contamination of streambed sediment in the Salem area. Biological testing is suggested by the guidelines, and some studies are in progress by the City of Salem (Jeanne Miller, City of Salem, written commun., 2002). There may be other ways to further characterize the sources and extent of this contamination. The source(s) of PAHs at the Shelton Ditch site are hard to pinpoint from the present study because it was not possible to determine the contributing basin area for this site. Further on-the-ground investigations and sampling may indicate possible contamination sources for the Shelton Ditch site. PAHs can accumulate in streambed sediments by way of airborne transport, so air quality of the area around Shelton Ditch should also be considered.

Measurement of organochlorine compounds in fish tissue may elucidate the ecological distribution of these compounds in the Salem area. There were exceedances of screening values for several DDT, DDE, and DDD compounds at eight sites (table 9). Since concentrations of organochlorine compounds (normalized to lipid content) generally are larger in fish tissue than in streambed sediment due to bioaccumulation (Wentz and others, 1998b), the analysis of fish tissue may reveal further occurrences of organochlorine compounds. If resident fish from these streams are being consumed by humans and wildlife, fish tissue analyses would be helpful to determine the health risk associated with fish consumption.

It would be appropriate to test for dieldrin in fish tissue since dieldrin was detected in unfiltered water samples from Pringle Creek in 1994 (Anderson and others, 1996), causing Pringle Creek to be listed as water-quality limited by the Oregon Department of Environmental Quality in 1998. Although dieldrin was not found in elevated concentrations in streambed sediment in this study, it is possible that bioaccumulation has caused it to be concentrated in fish tissue. In the Tualatin Basin, another predominantly urban area in the Willamette Valley, concentrations of total chlordane and polychlorinated biphenyl exceeded criteria for fish tissue (Bonn, 1999). It also may be appropriate to test for these compounds in fish in Salem area streams. It would be informative to collect data in Salem area streams concerning fish species diversity and abundance. Fish populations at urban-impacted sites in the Tualatin Basin were low (Bonn, 1999), and the same situation might be expected in the Salem area.

Further monitoring of the water column in the Salem area streams could also yield useful information. Many of the organic chemicals targeted by the present study are hydrophobic, so they are expected to be found in a more concentrated condition in sediment and fish tissue. However, other constituents, such as currently used water-soluble herbicides like atrazine and 2,4-D, are more commonly found dissolved in the water column. Some of these constituents are more likely to be found in the initial runoff from storms following pesticide application (Anderson and others, 1997), so sampling needs to be carefully coordinated with meteorological and hydrological conditions. Bacterial contamination by *E. coli* bacteria and fecal coliform has also been documented in the Oregon Department of Environmental Quality 303(d) list of water-quality-limited streams, and may merit further study.

Clark Creek

The streambed sediment sample from Clark Creek had the highest concentration of at least one of each class of the semivolatile organic chemicals. The Clark Creek sample had the highest concentration of every analyzed PAH (except for acenaphthene and phenanthrene, which were highest at Shelton Ditch). The sample from Clark Creek exceeded the PSDDA and Canadian interim PEL screening values for several of the organochlorines and PAHs (table 9). Additionally, Clark Creek streambed sediment had the highest concentration for cadmium, chromium, lead, and zinc. Concentrations in Clark Creek exceeded PSDDA and/or CCME guidelines for lead and zinc (table 9).

The basin above the Clark Creek site was 100 percent urban land use (table 1). Urban and industrial activities may be the source of organic chemicals and elements in the streambed sediment sample from Clark Creek. A closer examination of streambed-sediment chemistry at various points along the stream may indicate the exact causes.

East Fork of Pringle Creek

The East Fork of Pringle Creek had the highest concentrations of the DDD, DDE, and DDT compounds (table 11). Total DDD and total DDE exceeded the CCME screening level guideline (table 9). Total DDT exceeded the maximum level guideline by a factor of more than 5 (see text above). DDT is an organochlorine insecticide that was commonly used in the United States in the 1950s and 1960s. Although it was later banned, DDT and its degradation products, DDD and DDE, are common in the environment. The drainage basin for the East Fork of Pringle Creek is 87 percent urban, with smaller areas of other land uses (table 1). DDT once was used in urban areas for insect control. It is possible that DDT and other pesticides were used and stored in the Pringle Creek area—that would explain the presence of these chemicals that was documented in the present study.

Aldrin was detected in streambed sediment at only one site, the East Fork of Pringle Creek. (This detection was at the detection level of 1 μg/kg.) This detection of aldrin was unusual—fewer than 5 percent

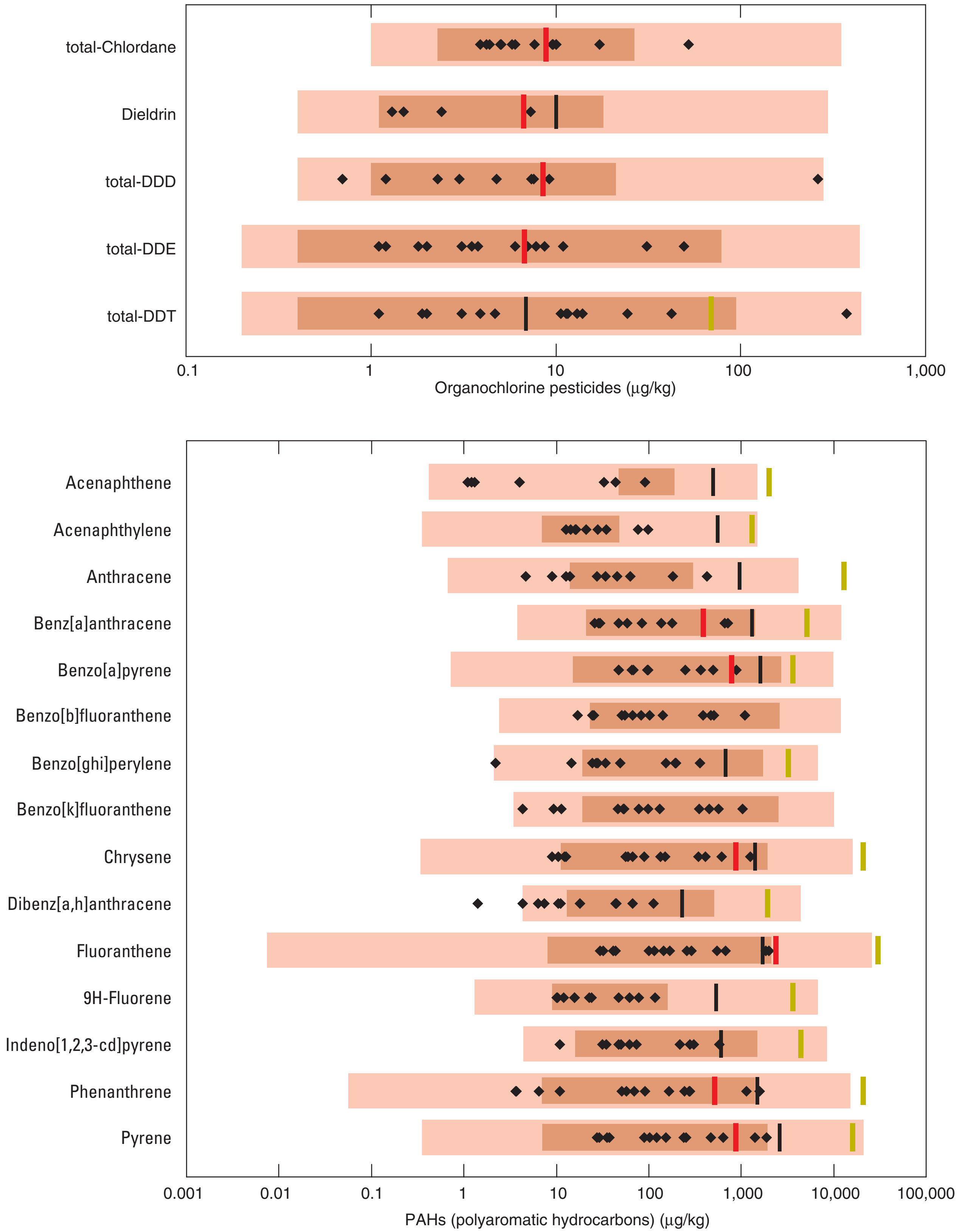

Figure 3. Comparison of concentrations of organic chemicals in streambed sediment samples from the Salem area with Willamette Basin concentrations, nationwide concentrations, and sediment quality guidelines. [Total DDD is the sum of *o,p'*-DDD and *p,p'*-DDD; total DDE is the sum of *o,p'*-DDE and *p,p'*-DDE; and total DDT is the sum of *p,p'*-DDD, *p,p'*-DDE, and *p,p'*-DDT. Willamette Basin data are from 1992 to 1995 (Wentz and others, 1998a), and nationwide data are from 1992 to 1997 (U.S. Geological Survey, 2002). Probable effects levels are from the Canadian Council of Ministers of the Environment, 2001; screening levels and maximum levels are from the Puget Sound Dredged Disposal Analysis Program, 2000.

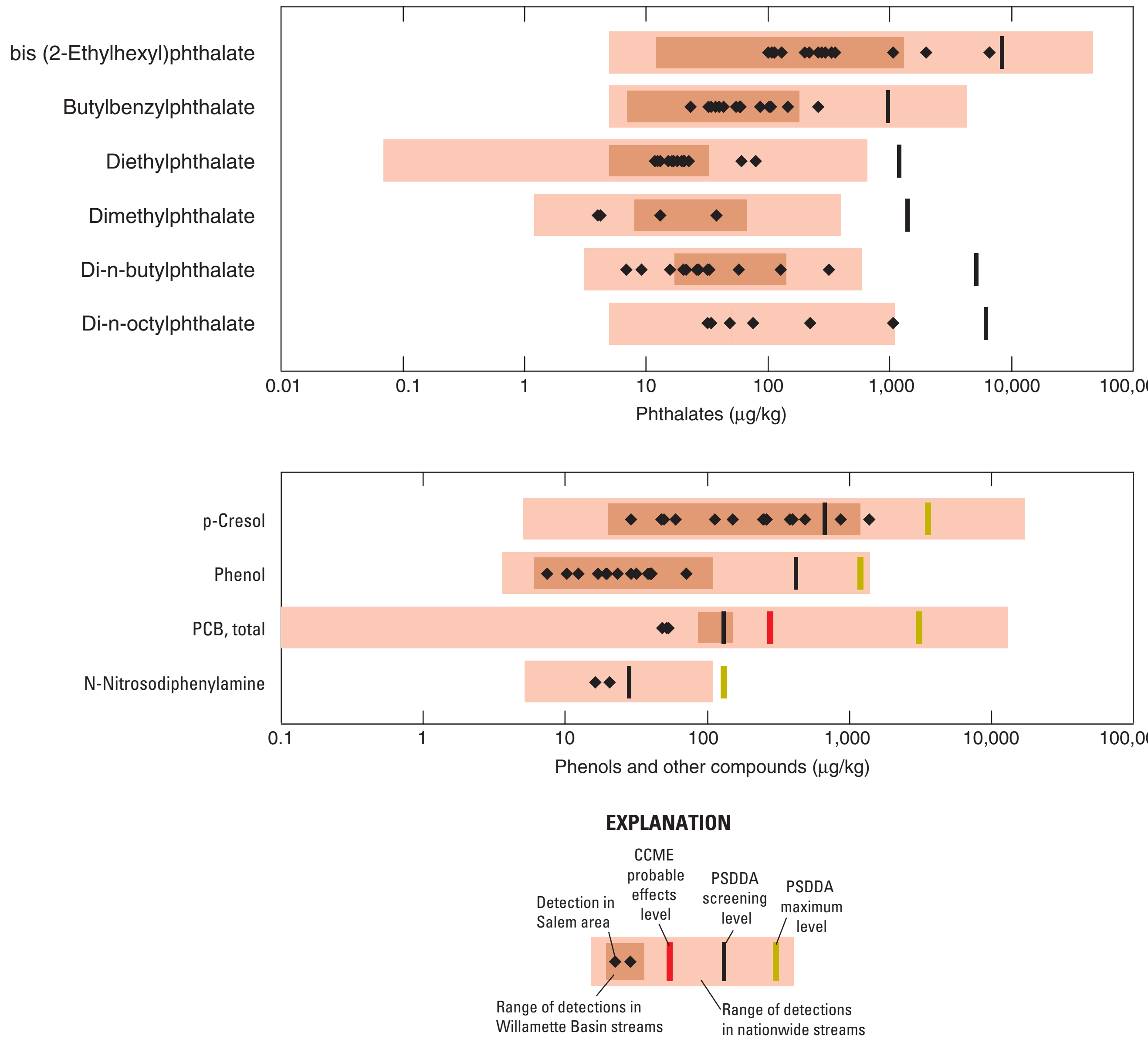

Figure 3. Continued.

of the NAWQA streambed sediment samples nationwide showed aldrin detections (United States Geological Survey, 2002). Aldrin and dieldrin are organochlorine insecticides with similar chemical structures; all uses of both chemicals were banned by the USEPA in 1987. Aldrin degrades naturally into dieldrin, which can become stored in lipid tissue (Smith and others, 1998). Dieldrin was detected in four of the Salem-area streambed sediment samples, including Pringle Creek (table 11 and appendix A) and in unfiltered water samples from Pringle Creek near the mouth (Anderson and others, 1996). It is possible that there is a common source of aldrin (and ultimately for dieldrin) in the drainage basin of the East Fork of Pringle Creek. Follow up testing of invertebrate and fish tissues for these compounds could help assess potential hazards to humans.

SUMMARY

Streambed sediment samples were collected from 14 sites on streams in the Salem area in October 1999. USGS laboratories analyzed the sediment samples for elements, organochlorine pesticides, pesticide metabolites, PCBs, semivolatile organic chemicals (PAHs, phthalates, and phenols), organic carbon content, and fraction of grain size less than 63 µm. Quality

Table 11. Summary statistics for organic chemical concentrations in streambed sediment samples, Salem area, Oregon, 1999

[All concentrations in micrograms per kilogram dry weight (μg/kg). Abbreviation: E, estimated value]

Organic chemical	Reporting level (μg/kg)	Number of detections in 14 samples	Maximum concentration (μg/kg)	Site of maximum concentration
Organochlorine pesticides				
aldrin	1	1	1	East Fork of Pringle Creek
cis-chlordane	1	11	14	Clark Creek
trans-chlordane	1	11	12	Clark Creek
dieldrin	1	4	E 7	Clark Creek
o,p'-DDD	1	2	41	East Fork of Pringle Creek
p,p'-DDD	1	9	E 220	East Fork of Pringle Creek
o,p'-DDE	1	1	6	East Fork of Pringle Creek
p,p'-DDE	1	14	44	East Fork of Pringle Creek
o,p'-DDT	2	1	7	East Fork of Pringle Creek
p,p'-DDT	2	8	E 110	East Fork of Pringle Creek
cis-nonachlor	1	4	E 4	Clark Creek
trans-nonachlor	1	11	12	Clark Creek
The following organochlorine pesticides were not detected in streambed sediment: chloroneb, dacthal, endosulfan I, endrin, α-HCH, β-HCH, γ-HCH (lindane), heptachlor, heptachlor epoxide, isodrin, *o,p'*-methoxychlor, *p,p'*-methoxychlor, mirex, oxy-chlordane, *cis*-permethrin, *trans*-permethrin, toxaphene.				
PAHs (polycyclic aromatic hydrocarbons)				
acenaphthene	50	8	90	Shelton Ditch
acenaphthylene	50	9	E 100	Clark Creek
anthracene	50	10	E 180	Clark Creek
benz[*a*]anthracene	50	10	700	Clark Creek
benzo[*a*]pyrene	50	10	880	Clark Creek
benzo[*b*]fluoranthene	50	13	1,100	Clark Creek
benzo[*ghi*]perylene	50	11	E 360	Clark Creek
benzo[*k*]fluoranthene	50	13	1000	Clark Creek
chrysene	50	14	1,200	Clark Creek
dibenz[*a,h*]anthracene	50	11	E 110	Clark Creek
fluoranthene	50	14	2,000	Clark Creek
9H-fluorene	50	11	E 120	Clark Creek
indeno[1,2,3-*cd*]pyrene	50	11	E 580	Clark Creek
phenanthrene	50	14	1,600	Shelton Ditch
pyrene	50	14	1,900	Clark Creek
Naphthalene was not detected in streambed sediment.				
Alkyl-PAHs				
1,6-dimethylnaphthalene	50	5	E 10.9	Shelton Ditch
2,6-dimethylnaphthalene	50	14	E 93.1	Claggett Creek
2-ethylnaphthalene	50	1	E 2.2	Shelton Ditch
1-methylphenanthrene	50	1	61.8	Shelton Ditch
1-methylpyrene	50	11	E 146	Clark Creek
2-methylanthracene	50	1	E 45.8	Shelton Ditch
4,5-methylenephenanthrene (49411)	50	9	E 160	Clark Creek
2,3,6-trimethylnaphthylene	50	1	E 4	Shelton Ditch
The following alkyl-PAHs were not detected in streambed sediment: 1,2-dimethylnaphthalene, 1-methyl-9H-fluorene.				

Table 11. Summary statistics for organic chemical concentrations in streambed sediment samples, Salem area, Oregon, 1999—Continued

[All concentrations in micrograms per kilogram dry weight (μg/kg). Abbreviation: E, estimated value]

Organic chemical	Reporting level (μg/kg)	Number of detections in 14 samples	Maximum concentration (μg/kg)	Site of maximum concentration
Azaarines				
acridine	50	7	E 69.7	Clark Creek
2,2'-biquinoline	50	1	E 49.4	Glenn Creek
9H-carbazole	50	3	212	Shelton Ditch
phenanthridine	50	1	E 12.4	Shelton Ditch
The following azaarines were not detected in streambed sediment: benzo[*c*]cinnoline, isoquinoline, and quinoline.				
Phthalates				
bis(2-ethylhexyl)phthalate	50	14	6,560	Clark Creek
butylbenzylphthalate	50	[a]14	E 258	Clark Creek
diethylphthalate	50	13	E 78.9	Clark Creek
dimethylphthalate	50	4	E 37.7	Pringle Creek
di-*n*-butylphthalate	50	12	E 317	Clark Creek
di-*n*-octylphthalate	50	6	E 1,070	Clark Creek
Phenols				
C8-alkylphenol	50	1	E 9.3	Pringle Creek
p-cresol	50	14	1,370	Clark Creek
3,5-dimethylphenol	50	1	E 18.3	Pringle Creek
phenol	50	14	E 71.1	Clark Creek
The following phenols were not detected in streambed sediment: 2-chlorophenol, 4-chloro-3-methylphenol.				
Chlorinated aromatic compounds				
hexachlorobenzene	50	2	7.4	Pringle Creek
total PCB	50	3	E 53	Pringle Creek
The following chlorinated organic compounds were not detected in streambed sediment: 2-chloronaphthalene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, pentachloroanisole, pentachloronitrobenzene, and 1,2,4-trichlorobenzene.				
Other				
anthraquinone	50	13	574	Clark Creek
dibenzothiophene	50	8	E 173	Clark Creek
N-nitrosodiphenylamine	50	2	E 20.5	Pringle Creek
The following other compounds were not detected in streambed sediment: azobenzene, bis(2-chloroethoxy)methane, 4-bromophenyl-phenylether, 4-chlorophenyl-phenylether, 2,4-dinitrotoluene, isophorone, nitrobenzene, N-nitrosodi-*n*-propylamine.				

[a] At one site, Glenn Creek, the laboratory blank for the sample set indicated contamination larger than the reporting level (blank = 75.9 μg/kg). The reported butylbenzylphthalate value at Glenn Creek was E 60 μg/kg, therefore, it is likely that the reported butylbenzylphthalate value was the result of laboratory contamination.

assurance data from split samples, laboratory blanks, and organic-chemical surrogates indicated that laboratory procedures yielded results within expected ranges, with the exception of low-level butylbenzylphthalate contamination of the laboratory blank associated with one sample.

Sediment quality guidelines (SQGs) are numerical limits recommended to support and maintain designated uses of the aquatic environment. SQGs for comparison to the Salem-area data were from the Puget Sound Dredged Disposal Analysis Program (2000) and from the Canadian Council of Ministers of the Environment (2001). Two PSDDA guidelines were used for elements and organic chemicals, the smaller screening level (SL) and the larger maximum level (ML). The Canadian Council of Ministers of the Environment has established an interim guideline, the probable effect level (PEL), above which adverse biological effects are expected to occur frequently (Canadian Council of Ministers of the Environment, 2001).

There were anomalously large concentrations of some elements and organic chemicals in streambed sediments, indicating contamination from anthropogenic and/or geologic sources. The concentrations of elements were compared to the established break-points for the Willamette River Basin, and concentrations of cadmium and lead for the sample from Clark Creek, which drains a highly urbanized basin, were 5 times larger than the respective break-points. Zinc concentrations in the sample from Clark Creek exceeded both the PSDDA screening level guideline and the Canadian interim PEL.

Several organic chemicals were detected in the streambed sediment samples from the Salem area. The percentage of urban land use in the contributing drainage basin was positively correlated (Spearman's rho significant to the 0.05 probability level) with several PAHs and phthalates, and with total PCBs. These constituents often are the products of industrial activities, which are often located in urban areas.

The most commonly detected organochlorine pesticide was *p,p'*-DDE (a metabolite of DDT), which was detected at all of the sites. Total DDT concentrations (the sum of *p,p'*-DDD, *p,p'*-DDE, and *p,p'*-DDT) exceeded the PSDDA screening level at Claggett Creek, Clark Creek, East Fork of Pringle Creek, Gibson Creek, Glenn Creek, Mill Creek near mouth, Pettyjohn Creek, and Pringle Creek. The concentration of total DDT was 374 μg/kg at East Fork of Pringle Creek, and the PSDDA maximum level guideline was 69 μg/kg (Puget Sound Dredged Disposal Analysis, 2000). Since the concentration in the East Fork of Pringle Creek sample was more than twice the maximum level guideline, it would be considered unacceptable for disposal under guidelines, if the material were to be dredged.

Aldrin and dieldrin are organochlorine insecticides with similar chemical structures. Aldrin degrades naturally into dieldrin, which can become stored in lipid tissue. Detections of aldrin in streambed sediment are rare, but aldrin was detected at one site in the Salem area, the East Fork of Pringle Creek. Dieldrin was detected in four of the Salem-area streambed sediment samples, including the one from Pringle Creek, and in a previous study in unfiltered water samples from Pringle Creek. It is possible that there is a common source of aldrin (and ultimately for dieldrin) in the drainage basin of the East Fork of Pringle Creek.

The most commonly detected semivolatile compounds were PAHs, alkyl-PAHs, phthalates, *p*-cresol, phenol, and anthraquinone. Several PAHs exceeded screening guidelines at Clark Creek and Shelton Ditch, and *p*-cresol exceeded guidelines at Clark Creek and Pettyjohn Creek. The largest phthalate concentrations in Salem-area streambed sediments were somewhat larger than the Willamette Basin maxima, but in the same range as national maxima.

If the CCME and PSDDA guidelines were applied to the Salem-area streambed sediment samples, bioassays using benthic invertebrates would be part of future monitoring for 10 of the 14 sites that were sampled. Measurement of organochlorine compounds, including DDT, DDE, DDD, and dieldrin in fish tissue may elucidate the ecological distribution of these compounds in the Salem area. If resident fish from these streams are being consumed by humans and wildlife, fish tissue analyses would be helpful to determine the health risk associated with fish consumption.

Streambed sediment samples from Clark Creek and the East Fork of Pringle Creek had anomalously large concentrations of certain elements and organic compounds. Clark Creek, an urban basin, had large concentrations of PAHs, organochlorines, cadmium, lead, and zinc. The East Fork of Pringle Creek, which is a mostly urban basin, had the highest concentrations of the DDD, DDE, and DDT compounds. As previously mentioned, aldrin was detected in streambed sediment at only one site, the East Fork of Pringle Creek. This detection of aldrin was unusual—fewer than 5 percent of the NAWQA streambed sediment samples nationwide showed aldrin detections. It is possible that DDT and aldrin were used and stored in the Pringle Creek area.

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APPENDIXES

APPENDIX A. Streambed Sediment Data—Concentrations of elements and organic chemicals in streambed sediment samples, Salem area, Oregon, 1999

Abbreviations: OR, Oregon; NR, near; N, north; W, west; SED, sediment; BM, bottom material; WS, wet-seived; MM, millimeter; DW, dry weight; REC, recoverable, G, gram; KG, kilogram; U, micrometer; SUSP, suspended; BOT, bottom; MAT, material; UG, microgram; MM, millimeter; KG, kilogram; SURROGT, surrogate (for quality control purposes). Latitude and longitude are given in degrees, minutes, and seconds. The number in parentheses below each constituent name is the parameter code, as listed in table 2.

MULTIPLE STATION ANALYSES

STATION NAME	DATE	TIME	STATION NUMBER	LAT-I-TUDE	LONG-I-TUDE	CARBON, ORGANIC SED, BM WS,<2MM DW, REC (G/KG) (49271)
BATTLE CREEK NEAR INTERSTATE 5, OR	10-08-99	1010	445116123000300	44 51 16 N	123 00 03 W	38
CLAGGETT CREEK NEAR SALEM PARKWAY, OR	10-06-99	1150	445854123003100	44 58 54 N	123 00 31 W	25
CLARK CREEK UPSTREAM FROM PRINGLE CREEK, OR	10-13-99	1035	445538123015600	44 55 38 N	123 01 56 W	70
CROISAN CREEK NEAR MOUTH, OR	10-19-99	1310	445501123034300	44 55 01 N	123 03 43 W	34
EAST FORK OF PRINGLE CREEK NR 25TH AND MADRONA, OR	10-19-99	0950	445436123003300	44 54 36 N	123 00 33 W	36
GIBSON CREEK UPSTREAM FROM GLENN CREEK, OR	10-07-99	1000	445832123035700	44 58 32 N	123 03 57 W	34
GLENN CREEK UPSTREAM FROM GIBSON CREEK, OR	10-07-99	1430	445817123033300	44 58 17 N	123 03 33 W	31
MILL CREEK NEAR MOUTH, OR	10-15-99	1008	445705123021100	44 57 05 N	123 02 11 W	25
MILL CREEK UPSTREAM FROM MILL RACE, OR	10-12-99	1310	445602123005700	44 56 02 N	123 00 57 W	25
MILL CREEK UPSTREAM FROM SHELTON DITCH, OR	10-12-99	1010	445525122595300	44 55 25 N	122 59 53 W	18
MILL CREEK AT KUEBLER ROAD, OR	10-11-99	0955	445311122583500	44 53 11 N	122 58 35 W	50
PETTYJOHN CREEK AT HOMESTEAD ROAD, OR	10-20-99	1055	445436123051700	44 54 36 N	123 05 17 W	32
PRINGLE CREEK UPSTREAM FROM CLARK CREEK, OR	10-14-99	1010	445532123015400	44 55 32 N	123 01 54 W	52
SHELTON DITCH UPSTREAM FROM PRINGLE CREEK, OR	10-18-99	1133	445607123020700	44 56 07 N	123 02 07 W	19

STATION NAME	CARBON, ORGANIC SED, BM WS,<63U DW, REC (PER-CENT) (49266)	SED. SUSP. SIEVE DIAM. % FINER THAN .062 MM (70331)	ALUM-INUM BOT MAT <63U WS FIELD PERCENT (34790)	CALCIUM BOT MAT <63U WS FIELD PERCENT (34830)	IRON BOT MAT <63U WS FIELD PERCENT (34880)	MAGNE-SIUM BOT MAT <63U WS FIELD PERCENT (34900)	PHOS-PHORUS BOT MAT <63U WS FIELD PERCENT (34935)	POTAS-SIUM BOT MAT <63U WS FIELD PERCENT (34940)
BATTLE CREEK NEAR INTERSTATE 5, OR	4.1	78	10	.470	9.2	.320	.160	.410
CLAGGETT CREEK NEAR SALEM PARKWAY, OR	3.6	46	7.2	1.6	5.1	.850	.190	1.2
CLARK CREEK UPSTREAM FROM PRINGLE CREEK, OR	5.4	64	7.9	1.4	6.0	.770	.170	1.0
CROISAN CREEK NEAR MOUTH, OR	3.4	75	8.6	1.1	7.0	.600	.160	.890
EAST FORK OF PRINGLE CREEK NR 25TH AND MADRONA, OR	3.7	64	8.3	1.1	5.5	.670	.150	.920
GIBSON CREEK UPSTREAM FROM GLENN CREEK, OR	2.3	96	7.7	.960	5.6	.600	.130	1.4
GLENN CREEK UPSTREAM FROM GIBSON CREEK, OR	2.0	83	8.1	1.1	5.4	.660	.110	1.4
MILL CREEK NEAR MOUTH, OR	5.1	33	7.9	1.3	5.1	.660	.150	.780
MILL CREEK UPSTREAM FROM MILL RACE, OR	4.0	21	8.2	1.2	5.2	.640	.140	.760
MILL CREEK UPSTREAM FROM SHELTON DITCH, OR	4.3	42	8.3	1.1	5.1	.600	.130	.720
MILL CREEK AT KUEBLER ROAD, OR	4.6	66	8.0	1.1	5.0	.540	.140	.690
PETTYJOHN CREEK AT HOMESTEAD ROAD, OR	2.6	86	7.9	1.2	5.2	.680	.110	1.1
PRINGLE CREEK UPSTREAM FROM CLARK CREEK, OR	4.2	83	8.1	1.2	6.0	.690	.150	1.1
SHELTON DITCH UPSTREAM FROM PRINGLE CREEK, OR	5.4	19	8.0	1.3	5.1	.630	.150	.680

APPENDIX A. Streambed Sediment Data—Concentrations of elements and organic chemicals in streambed sediment samples, Salem area, Oregon, 1999—Continued

MULTIPLE STATION ANALYSES

STATION NAME	SODIUM BOT MAT <63U WS FIELD PERCENT (34960)	SULFUR BOT MAT <63U WS FIELD PERCENT (34970)	TITA-NIUM, SED, BM WS,<63U DRY WGT REC PERCENT (49274)	ANTI-MONY BOT MAT <63U WS FIELD (UG/G) (34795)	ARSENIC BOT MAT <63U WS FIELD (UG/G) (34800)	BARIUM BOT MAT <63U WS FIELD (UG/G) (34805)	BERYL-LIUM BOT MAT <63U WS FIELD (UG/G) (34810)	BISMUTH BOT MAT <180UWS FIELD (UG/G) (34816)
BATTLE CREEK NEAR INTERSTATE 5, OR	.320	.06	1.8	.6	4.4	420	1.9	<1
CLAGGETT CREEK NEAR SALEM PARKWAY, OR	1.2	.11	.680	1.5	7.6	520	1.5	<1
CLARK CREEK UPSTREAM FROM PRINGLE CREEK, OR	1.0	.13	.990	2.2	5.2	590	1.5	<1
CROISAN CREEK NEAR MOUTH, OR	.900	.05	1.2	.6	4.9	590	1.9	<1
EAST FORK OF PRINGLE CREEK NR 25TH AND MADRONA, OR	.900	.08	.920	.8	5.5	560	1.6	<1
GIBSON CREEK UPSTREAM FROM GLENN CREEK, OR	1.0	<.05	1.0	.6	5.2	670	2.1	<1
GLENN CREEK UPSTREAM FROM GIBSON CREEK, OR	1.1	<.05	.980	.7	4.2	660	1.7	<1
MILL CREEK NEAR MOUTH, OR	.900	.08	.830	1.2	5.7	440	1.8	<1
MILL CREEK UPSTREAM FROM MILL RACE, OR	.870	.06	.930	.6	4.7	440	1.5	<1
MILL CREEK UPSTREAM FROM SHELTON DITCH, OR	.880	.07	.880	.6	4.7	420	1.4	<1
MILL CREEK AT KUEBLER ROAD, OR	.880	.07	.880	.6	5.1	420	1.8	<1
PETTYJOHN CREEK AT HOMESTEAD ROAD, OR	1.1	.06	.860	.6	5.0	610	1.7	<1
PRINGLE CREEK UPSTREAM FROM CLARK CREEK, OR	.910	.08	.920	1.2	6.4	600	1.8	<1
SHELTON DITCH UPSTREAM FROM PRINGLE CREEK, OR	.840	.09	.850	.7	5.1	420	1.4	<1

STATION NAME	CADMIUM BOT MAT <63U WS FIELD (UG/G) (34825)	CERIUM BOT MAT <63U WS FIELD (UG/G) (34835)	CHRO-MIUM BOT MAT <63U WS FIELD (UG/G) (34840)	COBALT BOT MAT <63U WS FIELD (UG/G) (34845)	COPPER BOT MAT <63U WS FIELD (UG/G) (34850)	EURO-PIUM BOT MAT <63U WS FIELD (UG/G) (34855)	GALLIUM BOT MAT <63U WS FIELD (UG/G) (34860)	GOLD BOT MAT <63U WS FIELD (UG/G) (34870)
BATTLE CREEK NEAR INTERSTATE 5, OR	.3	78	79	43	48	2	26	<1
CLAGGETT CREEK NEAR SALEM PARKWAY, OR	1.1	67	76	20	64	2	16	<1
CLARK CREEK UPSTREAM FROM PRINGLE CREEK, OR	3.2	74	88	28	93	2	18	<1
CROISAN CREEK NEAR MOUTH, OR	.3	75	76	34	43	3	21	<1
EAST FORK OF PRINGLE CREEK NR 25TH AND MADRONA, OR	.6	67	74	24	51	2	19	<1
GIBSON CREEK UPSTREAM FROM GLENN CREEK, OR	.1	81	71	26	31	3	19	<1
GLENN CREEK UPSTREAM FROM GIBSON CREEK, OR	.1	80	72	27	36	3	19	<1
MILL CREEK NEAR MOUTH, OR	.5	61	71	22	57	2	17	<1
MILL CREEK UPSTREAM FROM MILL RACE, OR	.3	67	69	21	42	2	18	<1
MILL CREEK UPSTREAM FROM SHELTON DITCH, OR	.2	64	71	22	41	2	18	<1
MILL CREEK AT KUEBLER ROAD, OR	.6	61	66	23	40	2	17	<1
PETTYJOHN CREEK AT HOMESTEAD ROAD, OR	.1	70	76	24	40	2	18	<1
PRINGLE CREEK UPSTREAM FROM CLARK CREEK, OR	1.2	72	77	31	70	2	19	<1
SHELTON DITCH UPSTREAM FROM PRINGLE CREEK, OR	.3	62	69	21	47	2	17	<1

APPENDIX A. Streambed Sediment Data—Concentrations of elements and organic chemicals in streambed sediment samples, Salem area, Oregon, 1999—Continued

MULTIPLE STATION ANALYSES

STATION NAME	HOLMIUM BOT MAT <63U WS FIELD (UG/G) (34875)	LANTHA-NUM BOT MAT <63U WS FIELD (UG/G) (34885)	LEAD BOT MAT <63U WS FIELD (UG/G) (34890)	LITHIUM BOT MAT <63U WS FIELD (UG/G) (34895)	MANGA-NESE BOT MAT <63U WS FIELD (UG/G) (34905)	MERCURY BOT MAT <63U WS FIELD (UG/G) (34910)	MOLYB-DENUM BOT MAT <63U WS FIELD (UG/G) (34915)	NEODYM-IUM BOT MAT <63U WS FIELD (UG/G) (34920)
BATTLE CREEK NEAR INTERSTATE 5, OR	1	38	28	21	2100	.05	1.7	42
CLAGGETT CREEK NEAR SALEM PARKWAY, OR	<1	32	100	26	1300	.14	1.4	31
CLARK CREEK UPSTREAM FROM PRINGLE CREEK, OR	1	37	160	24	1400	.21	1.8	40
CROISAN CREEK NEAR MOUTH, OR	1	42	40	25	1800	.06	.9	44
EAST FORK OF PRINGLE CREEK NR 25TH AND MADRONA, OR	1	33	52	26	1500	.07	.9	35
GIBSON CREEK UPSTREAM FROM GLENN CREEK, OR	1	45	27	26	1000	.05	.8	46
GLENN CREEK UPSTREAM FROM GIBSON CREEK, OR	1	46	30	25	900	.05	.7	48
MILL CREEK NEAR MOUTH, OR	<1	30	96	25	1800	.12	.9	30
MILL CREEK UPSTREAM FROM MILL RACE, OR	<1	32	36	25	1200	.05	.8	34
MILL CREEK UPSTREAM FROM SHELTON DITCH, OR	<1	31	23	25	1400	.05	.8	32
MILL CREEK AT KUEBLER ROAD, OR	<1	30	29	24	1800	.06	.8	31
PETTYJOHN CREEK AT HOMESTEAD ROAD, OR	1	37	21	24	960	.07	.7	37
PRINGLE CREEK UPSTREAM FROM CLARK CREEK, OR	1	37	94	26	2900	.12	1.4	38
SHELTON DITCH UPSTREAM FROM PRINGLE CREEK, OR	<1	29	43	24	1400	.17	.9	31

STATION NAME	NICKEL BOT MAT <63U WS FIELD (UG/G) (34925)	NIOBIUM BOT MAT <63U WS FIELD (UG/G) (34930)	SCAN-DIUM BOT MAT <63U WS FIELD (UG/G) (34945)	SELE-NIUM BOT MAT <63U WS FIELD (UG/G) (34950)	SILVER BOT MAT <63U WS FIELD (UG/G) (34955)	STRON-TIUM BOT MAT <63U WS FIELD (UG/G) (34965)	TANTA-LUM BOT MAT <63U WS FIELD (UG/G) (34975)	THORIUM BOT MAT <63U WS FIELD (UG/G) (34980)
BATTLE CREEK NEAR INTERSTATE 5, OR	32	24	39	.8	.3	97	2	8
CLAGGETT CREEK NEAR SALEM PARKWAY, OR	33	14	19	.4	.4	250	1	8
CLARK CREEK UPSTREAM FROM PRINGLE CREEK, OR	34	16	24	.4	.3	240	1	7
CROISAN CREEK NEAR MOUTH, OR	29	18	28	.4	.2	200	2	8
EAST FORK OF PRINGLE CREEK NR 25TH AND MADRONA, OR	32	15	24	.3	.2	190	1	6
GIBSON CREEK UPSTREAM FROM GLENN CREEK, OR	23	18	23	.3	.2	200	2	9
GLENN CREEK UPSTREAM FROM GIBSON CREEK, OR	26	18	24	.2	.3	220	2	8
MILL CREEK NEAR MOUTH, OR	31	14	21	.3	.2	210	1	6
MILL CREEK UPSTREAM FROM MILL RACE, OR	29	14	23	.5	.2	200	1	6
MILL CREEK UPSTREAM FROM SHELTON DITCH, OR	32	14	23	.3	.2	200	1	6
MILL CREEK AT KUEBLER ROAD, OR	27	14	22	.3	.2	190	1	6
PETTYJOHN CREEK AT HOMESTEAD ROAD, OR	27	16	22	.3	.2	240	1	7
PRINGLE CREEK UPSTREAM FROM CLARK CREEK, OR	46	16	24	.3	.3	200	2	8
SHELTON DITCH UPSTREAM FROM PRINGLE CREEK, OR	30	13	22	.5	.2	200	1	6

APPENDIX A. Streambed Sediment Data—Concentrations of elements and organic chemicals in streambed sediment samples, Salem area, Oregon, 1999—Continued

MULTIPLE STATION ANALYSES

STATION NAME	TIN BOT MAT <63U WS FIELD (UG/G) (34985)	URANIUM BOT MAT <63U WS FIELD (UG/G) (35000)	VANA- DIUM BOT MAT <63U WS FIELD (UG/G) (35005)	YTTER- BIUM BOT MAT <63U WS FIELD (UG/G) (35015)	YTTRIUM BOT MAT <63U WS FIELD (UG/G) (35010)	ZINC BOT MAT <63U WS FIELD (UG/G) (35020)	ALDRIN, SED, BM WS,<2MM DW, REC (UG/KG) (49319)	CIS- CHLOR- DANE, SED, BM WS,<2MM DW, REC (UG/KG) (49320)
BATTLE CREEK NEAR INTERSTATE 5, OR	4	2.6	360	4	41	200	<1	M
CLAGGETT CREEK NEAR SALEM PARKWAY, OR	4	2.0	160	2	27	390	<5	E2
CLARK CREEK UPSTREAM FROM PRINGLE CREEK, OR	7	2.0	200	4	44	500	<10	14
CROISAN CREEK NEAR MOUTH, OR	3	2.2	240	4	49	210	<2	E2
EAST FORK OF PRINGLE CREEK NR 25TH AND MADRONA, OR	3	1.8	180	3	38	320	1	<2
GIBSON CREEK UPSTREAM FROM GLENN CREEK, OR	3	2.4	200	4	47	150	<1	2
GLENN CREEK UPSTREAM FROM GIBSON CREEK, OR	3	2.2	190	4	48	140	<1	M
MILL CREEK NEAR MOUTH, OR	10	2.0	170	3	29	290	<1	2
MILL CREEK UPSTREAM FROM MILL RACE, OR	4	2.0	180	3	31	160	<1	M
MILL CREEK UPSTREAM FROM SHELTON DITCH, OR	3	1.8	180	3	31	140	<2	<2
MILL CREEK AT KUEBLER ROAD, OR	3	1.8	170	3	31	150	<1	<1
PETTYJOHN CREEK AT HOMESTEAD ROAD, OR	3	2.3	170	4	37	150	<2	2
PRINGLE CREEK UPSTREAM FROM CLARK CREEK, OR	7	2.2	190	4	41	390	<2	2
SHELTON DITCH UPSTREAM FROM PRINGLE CREEK, OR	4	1.8	170	3	30	170	<1	M

STATION NAME	TRANS- CHLOR- DANE, SED, BM WS,<2MM DW, REC (UG/KG) (49321)	CHLORO- NEB, SED, BM WS,<2MM DW, REC (UG/KG) (49322)	DCPA, SED, BM WS,<2MM DW, REC (UG/KG) (49324)	O, P'- DDD, SED, BM WS,<2MM DW, REC (UG/KG) (49325)	P, P'- DDD, SED, BM WS,<2MM DW, REC (UG/KG) (49326)	O, P'- DDE, SED, BM WS,<2MM DW, REC (UG/KG) (49327)	P, P'- DDE, SED, BM WS,<2MM DW, REC (UG/KG) (49328)	O, P'- DDT, SED, BM WS,<2MM DW, REC (UG/KG) (49329)
BATTLE CREEK NEAR INTERSTATE 5, OR	M	<5	<5	<1	M	<1	1	<2
CLAGGETT CREEK NEAR SALEM PARKWAY, OR	E3	<25	<25	<5	8	<5	E4	<10
CLARK CREEK UPSTREAM FROM PRINGLE CREEK, OR	12	<50	<50	<10	E7	<10	E6	<20
CROISAN CREEK NEAR MOUTH, OR	E1	<10	<10	<2	<3	<2	3	<4
EAST FORK OF PRINGLE CREEK NR 25TH AND MADRONA, OR	<2	<10	<10	41	E220	6	44	7
GIBSON CREEK UPSTREAM FROM GLENN CREEK, OR	1	<5	<5	<1	3	<1	11	<2
GLENN CREEK UPSTREAM FROM GIBSON CREEK, OR	1	<5	<5	<2	9	<2	31	<2
MILL CREEK NEAR MOUTH, OR	1	<5	<5	1	4	<1	7	<2
MILL CREEK UPSTREAM FROM MILL RACE, OR	M	<5	<5	<1	1	<1	2	<2
MILL CREEK UPSTREAM FROM SHELTON DITCH, OR	<2	<10	<10	<2	<4	<3	4	<4
MILL CREEK AT KUEBLER ROAD, OR	<1	<5	<5	<1	<1	<2	2	<2
PETTYJOHN CREEK AT HOMESTEAD ROAD, OR	E2	<10	<10	<2	2	<2	9	<4
PRINGLE CREEK UPSTREAM FROM CLARK CREEK, OR	2	<10	<10	<8	<14	<5	8	<4
SHELTON DITCH UPSTREAM FROM PRINGLE CREEK, OR	M	<5	<5	<1	<1	<1	1	<2

APPENDIX A. Streambed Sediment Data—Concentrations of elements and organic chemicals in streambed sediment samples, Salem area, Oregon, 1999—Continued

MULTIPLE STATION ANALYSES

STATION NAME	P, P'-DDT, SED, BM WS,<2MM DW, REC (UG/KG) (49330)	DIEL-DRIN, SED, BM WS,<2MM DW, REC (UG/KG) (49331)	ENDO-SULFAN I, SED, BM WS,<2MM DW, REC (UG/KG) (49332)	ENDRIN, SED, BM WS,<2MM DW, REC (UG/KG) (49335)	ALPHA-BHC, SED, BM WS,<2MM DW, REC (UG/KG) (49338)	BETA-BHC, SED, BM WS,<2MM DW, REC (UG/KG) (49339)	LINDANE SED, BM WS,<2MM DW, REC (UG/KG) (49345)	HEPTA-CHLOR, SED, BM WS,<2MM DW, REC (UG/KG) (49341)
BATTLE CREEK NEAR INTERSTATE 5, OR	<2	<1	<1	<2	<1	<1	<1	<1
CLAGGETT CREEK NEAR SALEM PARKWAY, OR	<10	E2	<5	<10	<5	<5	<5	<5
CLARK CREEK UPSTREAM FROM PRINGLE CREEK, OR	E11	E7	<10	<20	<10	<10	<10	<10
CROISAN CREEK NEAR MOUTH, OR	<4	<2	<2	<4	<2	<2	<2	<2
EAST FORK OF PRINGLE CREEK NR 25TH AND MADRONA, OR	E110	<2	<2	<4	<2	<2	<2	<2
GIBSON CREEK UPSTREAM FROM GLENN CREEK, OR	<2	<1	<1	<2	<1	<1	<1	<1
GLENN CREEK UPSTREAM FROM GIBSON CREEK, OR	E2	<1	<1	<2	<1	<1	<1	<1
MILL CREEK NEAR MOUTH, OR	11	2	<1	<2	<1	<1	<1	<1
MILL CREEK UPSTREAM FROM MILL RACE, OR	M	<1	<1	<2	<1	<1	<1	<1
MILL CREEK UPSTREAM FROM SHELTON DITCH, OR	E1	<2	<2	<4	<2	<2	<2	<2
MILL CREEK AT KUEBLER ROAD, OR	<2	<1	<1	<2	<1	<1	<1	<1
PETTYJOHN CREEK AT HOMESTEAD ROAD, OR	M	<2	<2	<4	<2	<2	<2	<2
PRINGLE CREEK UPSTREAM FROM CLARK CREEK, OR	5	E1	<2	<4	<2	<2	<2	<2
SHELTON DITCH UPSTREAM FROM PRINGLE CREEK, OR	<2	<1	<1	<2	<1	<1	<1	<1

STATION NAME	HEPTA-CHLOR EPOXIDE SED, BM WS,<2MM DW, REC (UG/KG) (49342)	ISODRIN SED, BM WS,<2MM DW, REC (UG/KG) (49344)	METHOXY CHLOR, O,P'-, SED, BM WS,<2MM DW, REC (UG/KG) (49347)	METHOXY CHLOR P,P'-, SED, BM WS,<2MM DW, REC (UG/KG) (49346)	MIREX, SED, BM WS,<2MM DW, REC (UG/KG) (49348)	CIS-NONA-CHLOR, SED, BM WS,<2MM DW, REC (UG/KG) (49316)	TRANS-NONA-CHLOR, SED, BM WS,<2MM DW, REC (UG/KG) (49317)	OXY-CHLOR-DANE, SED, BM WS,<2MM DW, REC (UG/KG) (49318)
BATTLE CREEK NEAR INTERSTATE 5, OR	<1	<1	<5	<5	<1	<1	M	<1
CLAGGETT CREEK NEAR SALEM PARKWAY, OR	<5	<5	<25	<25	<5	<5	E2	<5
CLARK CREEK UPSTREAM FROM PRINGLE CREEK, OR	<10	<10	<50	<50	<10	E4	12	<10
CROISAN CREEK NEAR MOUTH, OR	<2	<2	<10	<10	<2	<2	E1	<2
EAST FORK OF PRINGLE CREEK NR 25TH AND MADRONA, OR	<2	<2	<10	<10	<2	<2	<2	<2
GIBSON CREEK UPSTREAM FROM GLENN CREEK, OR	<1	<1	<5	<5	<1	M	2	<1
GLENN CREEK UPSTREAM FROM GIBSON CREEK, OR	<1	<1	<5	<5	<1	<1	M	<1
MILL CREEK NEAR MOUTH, OR	<1	<1	<5	<5	<1	M	1	<1
MILL CREEK UPSTREAM FROM MILL RACE, OR	<1	<1	<5	<5	<1	<1	M	<1
MILL CREEK UPSTREAM FROM SHELTON DITCH, OR	<2	<2	<10	<10	<2	<2	<2	<2
MILL CREEK AT KUEBLER ROAD, OR	<1	<1	<5	<5	<1	<1	<1	<1
PETTYJOHN CREEK AT HOMESTEAD ROAD, OR	<2	<2	<10	<10	<2	E1	3	<2
PRINGLE CREEK UPSTREAM FROM CLARK CREEK, OR	<2	<2	<10	<10	<2	<2	E1	<2
SHELTON DITCH UPSTREAM FROM PRINGLE CREEK, OR	<1	<1	<5	<5	<1	<1	1	<1

APPENDIX A. Streambed Sediment Data—Concentrations of elements and organic chemicals in streambed sediment samples, Salem area, Oregon, 1999—Continued

MULTIPLE STATION ANALYSES

STATION NAME	CIS-PER-METHRIN SED, BM WS,<2MM DW, REC (UG/KG) (49349)	TRANS-PER-METHRIN SED, BM WS,<2MM DW, REC (UG/KG) (49350)	TOXA-PHENE SED, BM WS,<2MM DW, REC (UG/KG) (49351)	ACENAPH THENE SED, BM WS,<2MM DW, REC (UG/KG) (49429)	ACENAPH THYLENE SED, BM WS,<2MM DW, REC (UG/KG) (49428)	ANTHRA-CENE SED, BM WS,<2MM DW, REC (UG/KG) (49434)	BENZ(A) ANTHRA-CENE SED, BM WS,<2MM DW, REC (UG/KG) (49436)	BENZO (A) PYRENE SED, BM WS,<2MM DW, REC (UG/KG) (49389)
BATTLE CREEK NEAR INTERSTATE 5, OR	<5	<6	<200	<100	<100	<100	<100	<100
CLAGGETT CREEK NEAR SALEM PARKWAY, OR	<25	<25	<1000	M	E80	E30	E140	E360
CLARK CREEK UPSTREAM FROM PRINGLE CREEK, OR	<76	<150	<2000	E40	E100	E180	710	880
CROISAN CREEK NEAR MOUTH, OR	<31	<50	<400	E30	E20	E60	E80	E100
EAST FORK OF PRINGLE CREEK NR 25TH AND MADRONA, OR	<23	<88	<400	M	E30	E30	E60	E100
GIBSON CREEK UPSTREAM FROM GLENN CREEK, OR	<8	<13	<200	M	E20	E10	E30	E70
GLENN CREEK UPSTREAM FROM GIBSON CREEK, OR	<5	<5	<200	<100	<100	M	E50	E60
MILL CREEK NEAR MOUTH, OR	<11	<13	<200	<50	E10	E10	E30	E50
MILL CREEK UPSTREAM FROM MILL RACE, OR	<5	<5	<200	M	E10	M	E30	E50
MILL CREEK UPSTREAM FROM SHELTON DITCH, OR	<10	<39	<400	<100	<100	<100	<100	<100
MILL CREEK AT KUEBLER ROAD, OR	<34	<46	<200	<100	<100	<100	<100	<100
PETTYJOHN CREEK AT HOMESTEAD ROAD, OR	<10	<10	<400	<100	<100	<100	<100	<100
PRINGLE CREEK UPSTREAM FROM CLARK CREEK, OR	<35	<120	<400	M	E30	E50	180	250
SHELTON DITCH UPSTREAM FROM PRINGLE CREEK, OR	<11	<97	<200	90	E20	420	660	490

STATION NAME	BENZOB FLUOR-ANTHENE SED, BM WS,<2MM DW, REC (UG/KG) (49458)	BENZO(G HI)PERY LENE SED, BM WS,<2MM DW, REC (UG/KG) (49408)	BENZO K FLUOR-ANTHENE SED, BM WS,<2MM DW, REC (UG/KG) (49397)	CHRY-SENE SED, BM WS,<2MM DW, REC (UG/KG) (49450)	DIBENZ (AH),AN THRACEN SED, BM WS,<2MM DW, REC (UG/KG) (49461)	FLUOR-ANTHENE BED MAT WS <2MM DRY WGT REC (UG/KG) (49466)	9H-FLU-ORENE SED, BM WS,<2MM DW, REC (UG/KG) (49399)	INDENO 123-CD PYRENE SED, BM WS,<2MM DW, REC (UG/KG) (49390)
BATTLE CREEK NEAR INTERSTATE 5, OR	<100	M	<100	E10	M	E30	E10	E10
CLAGGETT CREEK NEAR SALEM PARKWAY, OR	E470	E190	E450	E410	E40	680	E60	E280
CLARK CREEK UPSTREAM FROM PRINGLE CREEK, OR	1100	E360	1000	1200	E110	2000	E120	E580
CROISAN CREEK NEAR MOUTH, OR	100	E30	E100	130	E10	260	E50	E50
EAST FORK OF PRINGLE CREEK NR 25TH AND MADRONA, OR	140	E30	130	150	E10	290	E20	E60
GIBSON CREEK UPSTREAM FROM GLENN CREEK, OR	E80	E30	E80	E90	M	170	E20	E50
GLENN CREEK UPSTREAM FROM GIBSON CREEK, OR	E70	E50	E50	E70	E20	140	<100	E70
MILL CREEK NEAR MOUTH, OR	50	E20	50	60	M	100	E10	E30
MILL CREEK UPSTREAM FROM MILL RACE, OR	50	E10	E50	60	M	120	E10	E30
MILL CREEK UPSTREAM FROM SHELTON DITCH, OR	E30	<100	M	E10	<100	E40	E20	<100
MILL CREEK AT KUEBLER ROAD, OR	E20	<100	E10	E10	<100	E40	<100	<100
PETTYJOHN CREEK AT HOMESTEAD ROAD, OR	E20	<100	M	M	<100	E30	<100	<100
PRINGLE CREEK UPSTREAM FROM CLARK CREEK, OR	380	E150	350	350	E40	550	E20	E220
SHELTON DITCH UPSTREAM FROM PRINGLE CREEK, OR	510	E200	570	610	E70	1800	80	E300

APPENDIX A. Streambed Sediment Data—Concentrations of elements and organic chemicals in streambed sediment samples, Salem area, Oregon, 1999—Continued

MULTIPLE STATION ANALYSES

STATION NAME	NAPHTH- ALENE, SED, BM WS,<2MM DW, REC (UG/KG) (49402)	PHENAN THRENE SED, BM WS,<2MM DW, REC (UG/KG) (49409)	PYRENE, SED, BM WS,<2MM DW, REC (UG/KG) (49387)	NAPTHAL ENE, 12 DIMETHL SED, BM WS,<2MM DW, REC (UG/KG) (49403)	NAPTHAL ENE, 16 DIMETHL SED, BM WS,<2MM DW, REC (UG/KG) (49404)	NAPTHAL ENE, 26 DIMETHL SED, BM WS,<2MM DW, REC (UG/KG) (49406)	NAPTHAL ENE, 2- ETHYL- SED BM WS <2MM DW REC (UG/KG) (49948)	9H-FLU- ORENE, 1METHYL SED, BM WS,<2MM DW, REC (UG/KG) (49398)
BATTLE CREEK NEAR INTERSTATE 5, OR	<100	M	E30	<100	<100	E10	<100	<100
CLAGGETT CREEK NEAR SALEM PARKWAY, OR	<500	E280	640	<500	<500	E90	<500	<500
CLARK CREEK UPSTREAM FROM PRINGLE CREEK, OR	<500	1100	1900	<500	<500	E70	<500	<500
CROISAN CREEK NEAR MOUTH, OR	<100	270	240	<100	M	E20	<100	<100
EAST FORK OF PRINGLE CREEK NR 25TH AND MADRONA, OR	<100	170	250	<100	M	E80	<100	<100
GIBSON CREEK UPSTREAM FROM GLENN CREEK, OR	<100	E90	150	<100	M	E40	<100	<100
GLENN CREEK UPSTREAM FROM GIBSON CREEK, OR	<100	E50	120	<100	<100	E30	<100	<100
MILL CREEK NEAR MOUTH, OR	<50	60	90	<50	<50	M	<50	<50
MILL CREEK UPSTREAM FROM MILL RACE, OR	<50	70	100	<50	<50	M	<50	<50
MILL CREEK UPSTREAM FROM SHELTON DITCH, OR	<100	M	E40	<100	<100	E30	<100	<100
MILL CREEK AT KUEBLER ROAD, OR	<100	E10	E40	<100	<100	E30	<100	<100
PETTYJOHN CREEK AT HOMESTEAD ROAD, OR	<100	M	E30	<100	<100	E30	<100	<100
PRINGLE CREEK UPSTREAM FROM CLARK CREEK, OR	<100	240	460	<100	M	E30	<100	<100
SHELTON DITCH UPSTREAM FROM PRINGLE CREEK, OR	<50	1600	1400	<50	E10	E30	M	<50

STATION NAME	PHENAN THRENE 1METHYL SED, BM WS,<2MM DW, REC (UG/KG) (49410)	PYRENE, 1- METHYL, SED, BM WS,<2MM DW, REC (UG/KG) (49388)	ANTHRA- CENE,2- METHYL- SED, BM WS,<2MM DW, REC (UG/KG) (49435)	4HCYPEN PHENAN THRENE SED, BM WS,<2MM DW, REC (UG/KG) (49411)	NAPTHAL ENE,236 TRIMETH SED, BM WS,<2MM DW, REC (UG/KG) (49405)	ACRI- DINE SED, BM WS,<2MM DW, REC (UG/KG) (49430)	BENZOCI NNOLINE BED MAT WS <2MM DRY WGT REC (UG/KG) (49468)	2,2'-BI QUINO- LINE, SED, BM WS,<2MM DW, REC (UG/KG) (49391)
BATTLE CREEK NEAR INTERSTATE 5, OR	<100	<100	<100	<100	<100	<100	<100	<100
CLAGGETT CREEK NEAR SALEM PARKWAY, OR	<500	E90	<500	E40	<500	<500	<500	<500
CLARK CREEK UPSTREAM FROM PRINGLE CREEK, OR	<500	E150	<500	E160	<500	E70	<500	<500
CROISAN CREEK NEAR MOUTH, OR	<100	E20	<100	E40	<100	M	<100	<100
EAST FORK OF PRINGLE CREEK NR 25TH AND MADRONA, OR	<100	E30	<100	E20	<100	M	<100	<100
GIBSON CREEK UPSTREAM FROM GLENN CREEK, OR	<100	E20	<100	E10	<100	M	<100	<100
GLENN CREEK UPSTREAM FROM GIBSON CREEK, OR	<100	E10	<100	<100	<100	<100	<100	E50
MILL CREEK NEAR MOUTH, OR	<50	E10	<50	M	<50	<50	<50	<50
MILL CREEK UPSTREAM FROM MILL RACE, OR	<50	E10	<50	M	<50	M	<50	<50
MILL CREEK UPSTREAM FROM SHELTON DITCH, OR	<100	E20	<100	<100	<100	<100	<100	<100
MILL CREEK AT KUEBLER ROAD, OR	<100	<100	<100	<100	<100	<100	<100	<100
PETTYJOHN CREEK AT HOMESTEAD ROAD, OR	<100	<100	<100	<100	<100	<100	<100	<100
PRINGLE CREEK UPSTREAM FROM CLARK CREEK, OR	<100	E30	<100	E30	<100	E20	<100	<100
SHELTON DITCH UPSTREAM FROM PRINGLE CREEK, OR	60	E50	E50	80	M	E10	<50	<50

APPENDIX A. Streambed Sediment Data—Concentrations of elements and organic chemicals in streambed sediment samples, Salem area, Oregon, 1999—Continued

MULTIPLE STATION ANALYSES

STATION NAME	CARBA- ZOLE SED, BM WS,<2MM DW, REC (UG/KG) (49449)	ISO- QUINO- LINE, SED, BM WS,<2MM DW, REC (UG/KG) (49394)	PHENAN- THRI- DINE SED, BM WS,<2MM DW, REC (UG/KG) (49393)	QUINO- LINE, SED, BM WS,<2MM DW, REC (UG/KG) (49392)	PHTHALA TE,BIS2 ETHHEXL SED, BM WS,<2MM DW, REC (UG/KG) (49426)	PHTHALA TEBUTYL BENZYL- SED, BM WS,<2MM DW, REC (UG/KG) (49427)	PHTHAL- ATE, D IETHYL SED, BM WS,<2MM DW, REC (UG/KG) (49383)	PHTHAL- ATE,DI- METHYL SED, BM WS,<2MM DW, REC (UG/KG) (49384)
BATTLE CREEK NEAR INTERSTATE 5, OR	<100	<100	<100	<100	200	E40	E20	<100
CLAGGETT CREEK NEAR SALEM PARKWAY, OR	<500	<500	<500	<500	2000	E100	E60	<500
CLARK CREEK UPSTREAM FROM PRINGLE CREEK, OR	M	<500	<500	<500	6600	E260	E80	<500
CROISAN CREEK NEAR MOUTH, OR	<100	<100	<100	<100	220	E90	E20	<100
EAST FORK OF PRINGLE CREEK NR 25TH AND MADRONA, OR	<100	<100	<100	<100	270	100	E20	E10
GIBSON CREEK UPSTREAM FROM GLENN CREEK, OR	<100	<100	<100	<100	350	E40	E20	<100
GLENN CREEK UPSTREAM FROM GIBSON CREEK, OR	<100	<100	<100	<100	130	E60	<100	<100
MILL CREEK NEAR MOUTH, OR	<50	<50	<50	<50	300	60	E10	M
MILL CREEK UPSTREAM FROM MILL RACE, OR	<50	<50	<50	<50	110	E30	E10	<50
MILL CREEK UPSTREAM FROM SHELTON DITCH, OR	<100	<100	<100	<100	110	E50	E20	<100
MILL CREEK AT KUEBLER ROAD, OR	<100	<100	<100	<100	260	E40	E20	<100
PETTYJOHN CREEK AT HOMESTEAD ROAD, OR	<100	<100	<100	<100	330	E20	E20	<100
PRINGLE CREEK UPSTREAM FROM CLARK CREEK, OR	E20	<100	<100	<100	1100	150	E20	E40
SHELTON DITCH UPSTREAM FROM PRINGLE CREEK, OR	210	<50	E10	<50	100	E30	E10	M

STATION NAME	PHTHAL- ATE, DIBUTYL SED, BM WS,<2MM DW, REC (UG/KG) (49381)	PHTHAL ATE, D IOCTYL SED, BM WS,<2MM DW, REC (UG/KG) (49382)	PHENOL C8- ALKYL- SED, BM WS,<2MM DW, REC (UG/KG) (49424)	PHENOL, 2CHLORO BED MAT WS <2MM DRY WGT REC (UG/KG) (49467)	M-CRE- SOL, 4- CHLORO- SED, BM WS,<2MM DW, REC (UG/KG) (49422)	P- CRESOL SED, BM WS,<2MM DW, REC (UG/KG) (49451)	3,5- XYLENOL SED, BM WS,<2MM DW, REC (UG/KG) (49421)	PHENOL SED, BM WS,<2MM DW, REC (UG/KG) (49413)
BATTLE CREEK NEAR INTERSTATE 5, OR	E60	E30	<100	<100	<100	E60	<100	E20
CLAGGETT CREEK NEAR SALEM PARKWAY, OR	E130	E220	<500	<500	<500	E380	<500	E40
CLARK CREEK UPSTREAM FROM PRINGLE CREEK, OR	E320	E1100	<500	<500	<500	1400	<500	E70
CROISAN CREEK NEAR MOUTH, OR	<100	<100	<100	<100	<100	250	<100	E20
EAST FORK OF PRINGLE CREEK NR 25TH AND MADRONA, OR	M	E50	<100	<100	<100	480	<100	E40
GIBSON CREEK UPSTREAM FROM GLENN CREEK, OR	E30	<100	<100	<100	<100	260	<100	E30
GLENN CREEK UPSTREAM FROM GIBSON CREEK, OR	E30	<100	<100	<100	<100	400	<100	E40
MILL CREEK NEAR MOUTH, OR	E30	<50	<50	<50	<50	E50	<50	E10
MILL CREEK UPSTREAM FROM MILL RACE, OR	E20	<50	<50	<50	<50	E50	<50	M
MILL CREEK UPSTREAM FROM SHELTON DITCH, OR	<100	E30	<100	<100	<100	150	<100	E30
MILL CREEK AT KUEBLER ROAD, OR	M	<100	<100	<100	<100	110	<100	E20
PETTYJOHN CREEK AT HOMESTEAD ROAD, OR	E20	<100	<100	<100	<100	870	<100	E20
PRINGLE CREEK UPSTREAM FROM CLARK CREEK, OR	E30	E80	M	<100	<100	250	E20	E40
SHELTON DITCH UPSTREAM FROM PRINGLE CREEK, OR	E20	<50	<50	<50	<50	E30	<50	E10

APPENDIX A. Streambed Sediment Data—Concentrations of elements and organic chemicals in streambed sediment samples, Salem area, Oregon, 1999—Continued

MULTIPLE STATION ANALYSES

STATION NAME	NAPTHAL ENE, 2- CHLORO- SED, BM WS,<2MM DW, REC (UG/KG) (49407)	BENZENE O-DI- CHLORO- SED, BM WS,<2MM DW, REC (UG/KG) (49439)	BENZENE M-DI- CHLORO- SED, BM WS,<2MM DW, REC (UG/KG) (49441)	BENZENE P-DI- CHLORO- SED, BM WS,<2MM DW, REC (UG/KG) (49442)	BENZENE HEXA- CHLORO- SED, BM WS,<2MM DW, REC (UG/KG) (49343)	PENTA- CHLORO- ANISOLE SED, BM WS,<2MM DW, REC (UG/KG) (49460)	BENZENE PNTCHLR NITRO- SED, BM WS,<2MM DW, REC (UG/KG) (49446)	PCB, SED, BM WS,<2MM DW, REC (UG/KG) (49459)
BATTLE CREEK NEAR INTERSTATE 5, OR	<100	<100	<100	<100	<1	<1	<100	<50
CLAGGETT CREEK NEAR SALEM PARKWAY, OR	<500	<500	<500	<500	<5	<5	<500	E50
CLARK CREEK UPSTREAM FROM PRINGLE CREEK, OR	<500	<500	<500	<500	E4	<10	<500	E50
CROISAN CREEK NEAR MOUTH, OR	<100	<100	<100	<100	<2	<2	<100	<100
EAST FORK OF PRINGLE CREEK NR 25TH AND MADRONA, OR	<100	<100	<100	<100	<2	<2	<100	<100
GIBSON CREEK UPSTREAM FROM GLENN CREEK, OR	<100	<100	<100	<100	<1	<1	<100	<50
GLENN CREEK UPSTREAM FROM GIBSON CREEK, OR	<100	<100	<100	<100	<1	<1	<100	<50
MILL CREEK NEAR MOUTH, OR	<50	<50	<50	<50	<1	<1	<50	<50
MILL CREEK UPSTREAM FROM MILL RACE, OR	<50	<50	<50	<50	<1	<1	<50	<50
MILL CREEK UPSTREAM FROM SHELTON DITCH, OR	<100	<100	<100	<100	<2	<2	<100	<100
MILL CREEK AT KUEBLER ROAD, OR	<100	<100	<100	<100	<1	<1	<100	<50
PETTYJOHN CREEK AT HOMESTEAD ROAD, OR	<100	<100	<100	<100	<2	<2	<100	<100
PRINGLE CREEK UPSTREAM FROM CLARK CREEK, OR	<100	<100	<100	<100	7	<2	<100	E50
SHELTON DITCH UPSTREAM FROM PRINGLE CREEK, OR	<50	<50	<50	<50	<1	<1	<50	<50

STATION NAME	BENZENE 124TRI- CHLORO- SED, BM WS,<2MM DW, REC (UG/KG) (49438)	9,10- ANTHRA- QUINONE SED, BM WS,<2MM DW, REC (UG/KG) (49437)	AZO- BENZENE SED, BM WS,<2MM DW, REC (UG/KG) (49443)	METHANE 2CHLORO ETHOXY SED, BM WS,<2MM DW, REC (UG/KG) (49401)	4-BROMO PHNPHNL ETHER SED, BM WS,<2MM DW, REC (UG/KG) (49454)	4CHLORO PHNPHN LETHER SED, BM WS,<2MM DW, REC (UG/KG) (49455)	THIOPH ENE,DI- BENZO- SED, BM WS,<2MM DW, REC (UG/KG) (49452)	TOLUENE 2,4-DI- NITRO- SED, BM WS,<2MM DW, REC (UG/KG) (49395)
BATTLE CREEK NEAR INTERSTATE 5, OR	<100	E30	<100	<100	<100	<100	<100	<100
CLAGGETT CREEK NEAR SALEM PARKWAY, OR	<500	E220	<500	<500	<500	<500	E120	<500
CLARK CREEK UPSTREAM FROM PRINGLE CREEK, OR	<500	570	<500	<500	<500	<500	E170	<500
CROISAN CREEK NEAR MOUTH, OR	<100	E70	<100	<100	<100	<100	E40	<100
EAST FORK OF PRINGLE CREEK NR 25TH AND MADRONA, OR	<100	120	<100	<100	<100	<100	<100	<100
GIBSON CREEK UPSTREAM FROM GLENN CREEK, OR	<100	E60	<100	<100	<100	<100	E30	<100
GLENN CREEK UPSTREAM FROM GIBSON CREEK, OR	<100	E40	<100	<100	<100	<100	<100	<100
MILL CREEK NEAR MOUTH, OR	<50	E50	<50	<50	<50	<50	E20	<50
MILL CREEK UPSTREAM FROM MILL RACE, OR	<50	E40	<50	<50	<50	<50	E20	<50
MILL CREEK UPSTREAM FROM SHELTON DITCH, OR	<100	<100	<100	<100	<100	<100	<100	<100
MILL CREEK AT KUEBLER ROAD, OR	<100	E40	<100	<100	<100	<100	<100	<100
PETTYJOHN CREEK AT HOMESTEAD ROAD, OR	<100	E40	<100	<100	<100	<100	<100	<100
PRINGLE CREEK UPSTREAM FROM CLARK CREEK, OR	<100	150	<100	<100	<100	<100	E40	<100
SHELTON DITCH UPSTREAM FROM PRINGLE CREEK, OR	<50	190	<50	<50	<50	<50	80	<50

APPENDIX A. Streambed Sediment Data—Concentrations of elements and organic chemicals in streambed sediment samples, Salem area, Oregon, 1999—Continued

MULTIPLE STATION ANALYSES

STATION NAME	ISOPHOR ONE SED, BM WS,<2MM DW, REC (UG/KG) (49400)	BENZENE NITRO- SED, BM WS,<2MM DW, REC (UG/KG) (49444)	DIPHNYL AMINE,N NITROSO SED, BM WS,<2MM DW, REC (UG/KG) (49433)	DPROPYL AMINE,N NITROSO SED, BM WS,<2MM DW, REC (UG/KG) (49431)	ALPHA- BHC, D6 SURROGT SED, BM WS,<2MM DW, REC PERCENT (49275)	BIPHENL 2FLUORO SURROGT SED, BM WS,<2MM DW, REC PERCENT (49279)	BENZENE NITROD5 SURROGT SED, BM WS,<2MM DW, REC PERCENT (49280)	TERPHEN YL D14- SURROGT SED, BM WS,<2MM DW, REC PERCENT (49278)
BATTLE CREEK NEAR INTERSTATE 5, OR	<100	<100	<100	<100	58	65	51	88
CLAGGETT CREEK NEAR SALEM PARKWAY, OR	<500	<500	<500	<500	54	46	67	70
CLARK CREEK UPSTREAM FROM PRINGLE CREEK, OR	<500	<500	<500	<500	65	47	83	66
CROISAN CREEK NEAR MOUTH, OR	<100	<100	<100	<100	90	56	44	87
EAST FORK OF PRINGLE CREEK NR 25TH AND MADRONA, OR	<100	<100	<100	<100	96	50	45	86
GIBSON CREEK UPSTREAM FROM GLENN CREEK, OR	<100	<100	<100	<100	56	68	65	96
GLENN CREEK UPSTREAM FROM GIBSON CREEK, OR	<100	<100	<100	<100	55	67	84	81
MILL CREEK NEAR MOUTH, OR	<50	<50	E20	<50	56	60	48	87
MILL CREEK UPSTREAM FROM MILL RACE, OR	<50	<50	<50	<50	63	63	53	88
MILL CREEK UPSTREAM FROM SHELTON DITCH, OR	<100	<100	<100	<100	86	57	54	84
MILL CREEK AT KUEBLER ROAD, OR	<100	<100	<100	<100	84	46	51	92
PETTYJOHN CREEK AT HOMESTEAD ROAD, OR	<100	<100	<100	<100	60	68	61	98
PRINGLE CREEK UPSTREAM FROM CLARK CREEK, OR	<100	<100	E20	<100	92	59	56	80
SHELTON DITCH UPSTREAM FROM PRINGLE CREEK, OR	<50	<50	<50	<50	59	64	58	91

Remark codes used in this report:
< -- Less than
E -- Estimated value
Null value remark codes used in this report:
M -- Presence verified, not quantified

APPENDIX B. Streambed Sediment Data—Streambed sediment quality assurance data , Salem area, Oregon, 1999

The number in parentheses below each constituent name is the parameter code, as listed in table 2. Abbreviations: SED, sediment; BM, bottom material; WS, wet-sieved; MM, millimeter; DW, dry weight; REC, recoverable, G, gram; KG, kilogram; U, micrometer; SUSP, suspended; BOT, bottom; MAT, material; UG, microgram; MM, millimeter; KG, kilogram.

MULTIPLE STATION ANALYSES

STATION NAME	DATE	CARBON, ORGANIC SED, BM WS,<2MM DW, REC (G/KG) (49271)	CARBON, ORGANIC SED, BM WS,<63U DW, REC (PER-CENT) (49266)	SED. SUSP. SIEVE DIAM. % FINER THAN .062 MM (70331)	ALUM-INUM BOT MAT <63U WS FIELD PERCENT (34790)	CALCIUM BOT MAT <63U WS FIELD PERCENT (34830)	IRON BOT MAT <63U WS FIELD PERCENT (34880)	MAGNE-SIUM BOT MAT <63U WS FIELD PERCENT (34900)
PRINGLE CREEK SPLIT SAMPLE	10-14-99	51	4.2	80	8.1	1.2	6.0	.700
PRINGLE CREEK SAMPLE	10-14-99	52	4.2	83	8.1	1.2	6.0	.690
CLARK CREEK SPLIT SAMPLE	10-13-99	71	5.3	68	7.9	1.4	5.8	.780
CLARK CREEK SAMPLE	10-13-99	70	5.4	64	7.9	1.4	6.0	.770

STATION NAME	PHOS-PHORUS BOT MAT <63U WS FIELD PERCENT (34935)	POTAS-SIUM BOT MAT <63U WS FIELD PERCENT (34940)	SODIUM BOT MAT <63U WS FIELD PERCENT (34960)	SULFUR BOT MAT <63U WS FIELD PERCENT (34970)	TITA-NIUM, SED, BM WS,<63U DRY WGT REC PERCENT (49274)	ANTI-MONY BOT MAT <63U WS FIELD (UG/G) (34795)	ARSENIC BOT MAT <63U WS FIELD (UG/G) (34800)	BARIUM BOT MAT <63U WS FIELD (UG/G) (34805)
PRINGLE CREEK SPLIT SAMPLE	.150	1.1	.930	.08	.920	1.2	5.9	620
PRINGLE CREEK SAMPLE	.150	1.1	.910	.08	.920	1.2	6.4	600
CLARK CREEK SPLIT SAMPLE	.170	1.0	1.1	.13	.970	2.0	5.2	590
CLARK CREEK SAMPLE	.170	1.0	1.0	.13	.990	2.2	5.2	590

STATION NAME	BERYL-LIUM BOT MAT <63U WS FIELD (UG/G) (34810)	BISMUTH BOT MAT <180UWS FIELD (UG/G) (34816)	CADMIUM BOT MAT <63U WS FIELD (UG/G) (34825)	CERIUM BOT MAT <63U WS FIELD (UG/G) (34835)	CHRO-MIUM BOT MAT <63U WS FIELD (UG/G) (34840)	COBALT BOT MAT <63U WS FIELD (UG/G) (34845)	COPPER BOT MAT <63U WS FIELD (UG/G) (34850)	EURO-PIUM BOT MAT <63U WS FIELD (UG/G) (34855)
PRINGLE CREEK SPLIT SAMPLE	1.9	<1	1.0	73	130	31	68	2
PRINGLE CREEK SAMPLE	1.8	<1	1.2	72	77	31	70	2
CLARK CREEK SPLIT SAMPLE	1.9	<1	3.3	72	85	28	92	2
CLARK CREEK SAMPLE	1.5	<1	3.2	74	88	28	93	2

STATION NAME	GALLIUM BOT MAT <63U WS FIELD (UG/G) (34860)	GOLD BOT MAT <63U WS FIELD (UG/G) (34870)	HOLMIUM BOT MAT <63U WS FIELD (UG/G) (34875)	LANTHA-NUM BOT MAT <63U WS FIELD (UG/G) (34885)	LEAD BOT MAT <63U WS FIELD (UG/G) (34890)	LITHIUM BOT MAT <63U WS FIELD (UG/G) (34895)	MANGA-NESE BOT MAT <63U WS FIELD (UG/G) (34905)	MERCURY BOT MAT <63U WS FIELD (UG/G) (34910)
PRINGLE CREEK SPLIT SAMPLE	19	<1	1	35	96	26	2800	.10
PRINGLE CREEK SAMPLE	19	<1	1	37	94	26	2900	.12
CLARK CREEK SPLIT SAMPLE	18	<1	1	36	160	24	1400	.24
CLARK CREEK SAMPLE	18	<1	1	37	160	24	1400	.21

MULTIPLE STATION ANALYSES

STATION NAME	MOLYBDENUM BOT MAT <63U WS FIELD (UG/G) (34915)	NEODYMIUM BOT MAT <63U WS FIELD (UG/G) (34920)	NICKEL BOT MAT <63U WS FIELD (UG/G) (34925)	NIOBIUM BOT MAT <63U WS FIELD (UG/G) (34930)	SCANDIUM BOT MAT <63U WS FIELD (UG/G) (34945)	SELENIUM BOT MAT <63U WS FIELD (UG/G) (34950)	SILVER BOT MAT <63U WS FIELD (UG/G) (34955)	STRONTIUM BOT MAT <63U WS FIELD (UG/G) (34965)
PRINGLE CREEK SPLIT SAMPLE	1.4	38	33	16	24	.3	.3	200
PRINGLE CREEK SAMPLE	1.4	38	46	16	24	.3	.3	200
CLARK CREEK SPLIT SAMPLE	1.6	40	34	16	24	.5	.3	230
CLARK CREEK SAMPLE	1.8	40	34	16	24	.4	.3	240

STATION NAME	TANTALUM BOT MAT <63U WS FIELD (UG/G) (34975)	THORIUM BOT MAT <63U WS FIELD (UG/G) (34980)	TIN BOT MAT <63U WS FIELD (UG/G) (34985)	URANIUM BOT MAT <63U WS FIELD (UG/G) (35000)	VANADIUM BOT MAT <63U WS FIELD (UG/G) (35005)	YTTERBIUM BOT MAT <63U WS FIELD (UG/G) (35015)	YTTRIUM BOT MAT <63U WS FIELD (UG/G) (35010)	ZINC BOT MAT <63U WS FIELD (UG/G) (35020)
PRINGLE CREEK SPLIT SAMPLE	1	8	7	2.4	190	4	41	380
PRINGLE CREEK SAMPLE	2	8	7	2.2	190	4	41	390
CLARK CREEK SPLIT SAMPLE	1	7	6	2.0	200	4	41	490
CLARK CREEK SAMPLE	1	7	7	2.0	200	4	44	500

STATION NAME	ALDRIN, SED, BM WS,<2MM DW, REC (UG/KG) (49319)	CIS-CHLORDANE, SED, BM WS,<2MM DW, REC (UG/KG) (49320)	TRANS-CHLORDANE, SED, BM WS,<2MM DW, REC (UG/KG) (49321)	CHLORONEB, SED, BM WS,<2MM DW, REC (UG/KG) (49322)	DCPA, SED, BM WS,<2MM DW, REC (UG/KG) (49324)	O, P'-DDD, SED, BM WS,<2MM DW, REC (UG/KG) (49325)	P, P'-DDD, SED, BM WS,<2MM DW, REC (UG/KG) (49326)	O, P'-DDE, SED, BM WS,<2MM DW, REC (UG/KG) (49327)
PRINGLE CREEK SPLIT SAMPLE	<1	2	2	<5	<5	<7	<14	<5
PRINGLE CREEK SAMPLE	<2	2	2	<10	<10	<8	<14	<5
CLARK CREEK SPLIT SAMPLE	<10	12	10	<50	<50	<10	E7	<10
CLARK CREEK SAMPLE	<10	14	12	<50	<50	<10	E7	<10

STATION NAME	P, P'-DDE, SED, BM WS,<2MM DW, REC (UG/KG) (49328)	O, P'-DDT, SED, BM WS,<2MM DW, REC (UG/KG) (49329)	P, P'-DDT, SED, BM WS,<2MM DW, REC (UG/KG) (49330)	DIELDRIN, SED, BM WS,<2MM DW, REC (UG/KG) (49331)	ENDOSULFAN I, SED, BM WS,<2MM DW, REC (UG/KG) (49332)	ENDRIN, SED, BM WS,<2MM DW, REC (UG/KG) (49335)	ALPHA-BHC, SED, BM WS,<2MM DW, REC (UG/KG) (49338)	BETA-BHC, SED, BM WS,<2MM DW, REC (UG/KG) (49339)
PRINGLE CREEK SPLIT SAMPLE	7	<2	4	1	<1	<2	<1	<1
PRINGLE CREEK SAMPLE	8	<4	5	E1	<2	<4	<2	<2
CLARK CREEK SPLIT SAMPLE	E6	<20	E14	E6	<10	<20	<10	<10
CLARK CREEK SAMPLE	E6	<20	E11	E7	<10	<20	<10	<10

APPENDIX B. Streambed Sediment Data—Streambed sediment quality assurance data , Salem area, Oregon, 1999—Continued

MULTIPLE STATION ANALYSES

STATION NAME	LINDANE SED, BM WS,<2MM DW, REC (UG/KG) (49345)	HEPTA- CHLOR, SED, BM WS,<2MM DW, REC (UG/KG) (49341)	HEPTA- CHLOR EPOXIDE SED, BM WS,<2MM DW, REC (UG/KG) (49342)	ISODRIN SED, BM WS,<2MM DW, REC (UG/KG) (49344)	METHOXY CHLOR, O,P'-, SED, BM WS,<2MM DW, REC (UG/KG) (49347)	METHOXY CHLOR P,P'-, SED, BM WS,<2MM DW, REC (UG/KG) (49346)	MIREX, SED, BM WS,<2MM DW, REC (UG/KG) (49348)	CIS- NONA- CHLOR, SED, BM WS,<2MM DW, REC (UG/KG) (49316)
PRINGLE CREEK SPLIT SAMPLE	<1	<1	<1	<1	<5	<5	<1	<1
PRINGLE CREEK SAMPLE	<2	<2	<2	<2	<10	<10	<2	<2
CLARK CREEK SPLIT SAMPLE	<10	<10	<10	<10	<50	<50	<10	E4
CLARK CREEK SAMPLE	<10	<10	<10	<10	<50	<50	<10	E4

STATION NAME	TRANS- NONA- CHLOR, SED, BM WS,<2MM DW, REC (UG/KG) (49317)	OXY- CHLOR- DANE, SED, BM WS,<2MM DW, REC (UG/KG) (49318)	CIS- PER- METHRIN SED, BM WS,<2MM DW, REC (UG/KG) (49349)	TRANS- PER- METHRIN SED, BM WS,<2MM DW, REC (UG/KG) (49350)	TOXA- PHENE SED, BM WS,<2MM DW, REC (UG/KG) (49351)	ACENAPH THENE SED, BM WS,<2MM DW, REC (UG/KG) (49429)	ACENAPH THYLENE SED, BM WS,<2MM DW, REC (UG/KG) (49428)	ANTHRA- CENE SED, BM WS,<2MM DW, REC (UG/KG) (49434)
PRINGLE CREEK SPLIT SAMPLE	M	<1	<48	<110	<200	M	E30	E40
PRINGLE CREEK SAMPLE	E1	<2	<35	<120	<400	M	E30	E50
CLARK CREEK SPLIT SAMPLE	10	<10	<89	<170	<2000	E90	E110	E260
CLARK CREEK SAMPLE	12	<10	<76	<150	<2000	E40	E100	E180

STATION NAME	BENZ(A) ANTHRA- CENE SED, BM WS,<2MM DW, REC (UG/KG) (49436)	BENZO (A) PYRENE SED, BM WS,<2MM DW, REC (UG/KG) (49389)	BENZOB FLUOR- ANTHENE SED, BM WS,<2MM DW, REC (UG/KG) (49458)	BENZO(G HI)PERY LENE SED, BM WS,<2MM DW, REC (UG/KG) (49408)	BENZO K FLUOR- ANTHENE SED, BM WS,<2MM DW, REC (UG/KG) (49397)	CHRY- SENE SED, BM WS,<2MM DW, REC (UG/KG) (49450)	DIBENZ (AH),AN THRACEN SED, BM WS,<2MM DW, REC (UG/KG) (49461)	FLUOR- ANTHENE BED MAT WS <2MM DRY WGT REC (UG/KG) (49466)
PRINGLE CREEK SPLIT SAMPLE	140	210	330	E120	310	280	E30	380
PRINGLE CREEK SAMPLE	180	250	380	E150	350	350	E40	550
CLARK CREEK SPLIT SAMPLE	940	1200	1200	E500	1500	1500	E160	2600
CLARK CREEK SAMPLE	710	880	1100	E360	1000	1200	E110	2000

STATION NAME	9H-FLU- ORENE SED, BM WS,<2MM DW, REC (UG/KG) (49399)	INDENO 123-CD PYRENE SED, BM WS,<2MM DW, REC (UG/KG) (49390)	NAPHTH- ALENE, SED, BM WS,<2MM DW, REC (UG/KG) (49402)	PHENAN THRENE SED, BM WS,<2MM DW, REC (UG/KG) (49409)	PYRENE, SED, BM WS,<2MM DW, REC (UG/KG) (49387)	NAPTHAL ENE, 12 DIMETHL SED, BM WS,<2MM DW, REC (UG/KG) (49403)	NAPTHAL ENE, 16 DIMETHL SED, BM WS,<2MM DW, REC (UG/KG) (49404)	NAPTHAL ENE, 26 DIMETHL SED, BM WS,<2MM DW, REC (UG/KG) (49406)
PRINGLE CREEK SPLIT SAMPLE	E20	E170	<100	190	310	<100	M	E30
PRINGLE CREEK SAMPLE	E20	E220	<100	240	460	<100	M	E30
CLARK CREEK SPLIT SAMPLE	E160	E690	<500	1700	2500	<500	M	E70
CLARK CREEK SAMPLE	E120	E580	<500	1100	1900	<500	<500	E70

MULTIPLE STATION ANALYSES

STATION NAME	NAPTHAL ENE, 2- ETHYL- SED BM WS <2MM DW REC (UG/KG) (49948)	9H-FLU- ORENE, 1METHYL SED, BM WS,<2MM DW, REC (UG/KG) (49398)	PHENAN THRENE 1METHYL SED, BM WS,<2MM DW, REC (UG/KG) (49410)	PYRENE, 1- METHYL, SED, BM WS,<2MM DW, REC (UG/KG) (49388)	ANTHRA- CENE,2- METHYL- SED, BM WS,<2MM DW, REC (UG/KG) (49435)	4HCYPEN PHENAN THRENE SED, BM WS,<2MM DW, REC (UG/KG) (49411)	NAPTHAL ENE,236 TRIMETH SED, BM WS,<2MM DW, REC (UG/KG) (49405)	ACRI- DINE SED, BM WS,<2MM DW, REC (UG/KG) (49430)
PRINGLE CREEK SPLIT SAMPLE	<100	<100	<100	E20	<100	E30	<100	E20
PRINGLE CREEK SAMPLE	<100	<100	<100	E30	<100	E30	<100	E20
CLARK CREEK SPLIT SAMPLE	<500	<500	<500	E160	<500	E210	<500	E100
CLARK CREEK SAMPLE	<500	<500	<500	E150	<500	E160	<500	E70

STATION NAME	BENZOCI NNOLINE BED MAT WS <2MM DRY WGT REC (UG/KG) (49468)	2,2'-BI QUINO- LINE, SED, BM WS,<2MM DW, REC (UG/KG) (49391)	CARBA- ZOLE SED, BM WS,<2MM DW, REC (UG/KG) (49449)	ISO- QUINO- LINE, SED, BM WS,<2MM DW, REC (UG/KG) (49394)	PHENAN- THRI- DINE SED, BM WS,<2MM DW, REC (UG/KG) (49393)	QUINO- LINE, SED, BM WS,<2MM DW, REC (UG/KG) (49392)	PHTHALA TE,BIS2 ETHHEXL SED, BM WS,<2MM DW, REC (UG/KG) (49426)	PHTHALA TEBUTYL BENZYL- SED, BM WS,<2MM DW, REC (UG/KG) (49427)
PRINGLE CREEK SPLIT SAMPLE	<100	<100	M	E10	<100	<100	1000	150
PRINGLE CREEK SAMPLE	<100	<100	E20	<100	<100	<100	1100	150
CLARK CREEK SPLIT SAMPLE	<500	E130	E90	<500	<500	<500	5600	E290
CLARK CREEK SAMPLE	<500	<500	M	<500	<500	<500	6600	E260

STATION NAME	PHTHAL- ATE, D IETHYL SED, BM WS,<2MM DW, REC (UG/KG) (49383)	PHTHAL- ATE,DI- METHYL SED, BM WS,<2MM DW, REC (UG/KG) (49384)	PHTHAL- ATE, DIBUTYL SED, BM WS,<2MM DW, REC (UG/KG) (49381)	PHTHAL ATE, D IOCTYL SED, BM WS,<2MM DW, REC (UG/KG) (49382)	PHENOL C8- ALKYL- SED, BM WS,<2MM DW, REC (UG/KG) (49424)	PHENOL, 2CHLORO BED MAT WS <2MM DRY WGT REC (UG/KG) (49467)	M-CRE- SOL, 4- CHLORO- SED, BM WS,<2MM DW, REC (UG/KG) (49422)	P- CRESOL SED, BM WS,<2MM DW, REC (UG/KG) (49451)
PRINGLE CREEK SPLIT SAMPLE	E30	E40	E30	E80	<100	<100	<100	290
PRINGLE CREEK SAMPLE	E20	E40	E30	E80	M	<100	<100	250
CLARK CREEK SPLIT SAMPLE	<500	<500	E390	E1300	<500	<500	<500	660
CLARK CREEK SAMPLE	E80	<500	E320	E1100	<500	<500	<500	1400

STATION NAME	3,5- XYLENOL SED, BM WS,<2MM DW, REC (UG/KG) (49421)	PHENOL SED, BM WS,<2MM DW, REC (UG/KG) (49413)	NAPTHAL ENE, 2- CHLORO- SED, BM WS,<2MM DW, REC (UG/KG) (49407)	BENZENE O-DI- CHLORO- SED, BM WS,<2MM DW, REC (UG/KG) (49439)	BENZENE M-DI- CHLORO- SED, BM WS,<2MM DW, REC (UG/KG) (49441)	BENZENE P-DI- CHLORO- SED, BM WS,<2MM DW, REC (UG/KG) (49442)	BENZENE HEXA- CHLORO- SED, BM WS,<2MM DW, REC (UG/KG) (49343)	PENTA- CHLORO- ANISOLE SED, BM WS,<2MM DW, REC (UG/KG) (49460)
PRINGLE CREEK SPLIT SAMPLE	<100	E40	<100	<100	<100	<100	4	<1
PRINGLE CREEK SAMPLE	E20	E40	<100	<100	<100	<100	7	<2
CLARK CREEK SPLIT SAMPLE	<500	<500	<500	<500	<500	<500	E3	<10
CLARK CREEK SAMPLE	<500	E70	<500	<500	<500	<500	E4	<10

MULTIPLE STATION ANALYSES

STATION NAME	BENZENE PNTCHLR NITRO- SED, BM WS,<2MM DW, REC (UG/KG) (49446)	PCB, SED, BM WS,<2MM DW, REC (UG/KG) (49459)	BENZENE 124TRI- CHLORO- SED, BM WS,<2MM DW, REC (UG/KG) (49438)	9,10- ANTHRA- QUINONE SED, BM WS,<2MM DW, REC (UG/KG) (49437)	AZO- BENZENE SED, BM WS,<2MM DW, REC (UG/KG) (49443)	METHANE 2CHLORO ETHOXY SED, BM WS,<2MM DW, REC (UG/KG) (49401)	4-BROMO PHNPHNL ETHER SED, BM WS,<2MM DW, REC (UG/KG) (49454)	4CHLORO PHNPHN LETHER SED, BM WS,<2MM DW, REC (UG/KG) (49455)
PRINGLE CREEK SPLIT SAMPLE	<100	E60	<100	130	<100	<100	<100	<100
PRINGLE CREEK SAMPLE	<100	E50	<100	150	<100	<100	<100	<100
CLARK CREEK SPLIT SAMPLE	<500	E60	<500	600	<500	<500	<500	<500
CLARK CREEK SAMPLE	<500	E50	<500	570	<500	<500	<500	<500

STATION NAME	THIOPH ENE,DI- BENZO- SED, BM WS,<2MM DW, REC (UG/KG) (49452)	TOLUENE 2,4-DI- NITRO- SED, BM WS,<2MM DW, REC (UG/KG) (49395)	ISOPHOR ONE SED, BM WS,<2MM DW, REC (UG/KG) (49400)	BENZENE NITRO- SED, BM WS,<2MM DW, REC (UG/KG) (49444)	DIPHNYL AMINE,N NITROSO SED, BM WS,<2MM DW, REC (UG/KG) (49433)	DPROPYL AMINE,N NITROSO SED, BM WS,<2MM DW, REC (UG/KG) (49431)
PRINGLE CREEK SPLIT SAMPLE	E30	<100	<100	<100	E20	<100
PRINGLE CREEK SAMPLE	E40	<100	<100	<100	E20	<100
CLARK CREEK SPLIT SAMPLE	E180	<500	<500	E30	<500	<500
CLARK CREEK SAMPLE	E170	<500	<500	<500	<500	<500

Remark codes used in this report:
< -- Less than
E -- Estimated value
Null value remark codes used in this report:
M -- Presence verified, not quantified

Tanner — **Selected Elements and Organic Chemicals in Streambed Sediment in the Salem Area, Oregon, 1999** — WRIR 02–4194

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