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PTI

ENVIRONMENTAL SERVICES

Draft Report Sections 1-7

BACKGROUND CONCENTRATIONS OF SELECTED CHEMICALS IN WATER, SOIL, SEDIMENTS, AND AIR OF WASHINGTON STATE

For

Washington Department of Ecology
Olympia, Washington

April 1989

PTI Environmental Services
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DRAFT REPORT SECTIONS 1-7

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1. INTRODUCTION

1.1 OBJECTIVE

The objective of this task is to identify the concentrations of selected high-priority contaminants that are representative of background (or ambient) conditions in the water, soil, air, and sediment of Washington state.

1.2 BACKGROUND

The Washington Department of Ecology (Ecology) is in the process of determining cleanup standards for selected contaminants in a variety of media (e.g., soil, water, air). Cleanup standards that are determined will subsequently be used to establish cleanup levels and remedial action requirements for hazardous waste sites throughout the state of Washington. Section 3(2)(d) of the Model Toxics Control Act requires the department to publish minimum cleanup standards that are at least as stringent as 1) the cleanup standards specified in Section 121 of the federal cleanup law [i.e., the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)], and 2) all applicable state and federal laws, including health-based standards under state and federal law.

The identification of representative ambient concentrations of selected contaminants is important to this process for two reasons:

1. One of the candidate cleanup alternatives is based on background concentration (or some function of background)

2. Background concentration is a useful index for comparing values derived for other alternatives (e.g., a risk-based value of 10 times less than background is clearly an unreasonable cleanup goal).

Ecology has identified categories of media of interest and has selected chemical contaminants to be evaluated in each medium. These media and chemicals are summarized in Table 1. Soil and groundwater are highest priority for background characterization, followed by fresh and marine sediments, fresh and marine surface water, and air.

1.3 DEFINITION

The term *background* as used in this report is defined in the broadest sense. Background is defined as the ambient concentration of a particular chemical in a particular area. Background is not used exclusively to represent pristine conditions, although the background concentration for an area isolated from anthropogenic activities may be considered representative of pristine conditions. Alternatively if the widespread use of pesticides in a broad geographical area (e.g., eastern Washington) resulted in an ambient concentration of some synthetic chemical, this concentration would be considered background for the area, and would be distinguished from localized hotspots of contamination. It must also be recognized that background concentrations range in value even in localized areas. Because of this, it is important to examine the underlying statistical distribution of the data.

1.4 APPROACH

The identification, collection, and evaluation of data sets considered to contain data representative of background is a task of potentially broad scope. The technical product is highly dependent on the number of categories of media identified, the number of variables (i.e., contaminants) identified for each medium, the relative priority of media and analytes, the number of data sets available, the number of general references reviewed, the level of quality assurance (QA) review applied to each data set, and the geographic representativeness of the data sets.

1.4.1 Data Identification and Collection

Because of resource limitations, techniques were developed to focus on the most comprehensive data sets believed to contain the highest quality data for the state of Washington. A two-step screening process was developed to accomplish this:

- **Step 1 - Preliminary Screening:** Data quality is evaluated based on conversations with agency and academic personnel. Data sets of uncertain quality are not pursued further.

TABLE 1. CONTAMINANTS OF CONCERN

Chemical	Soil	Groundwater	Sediment (Fresh and Marine)	Surface Water Fresh	Surface Water Marine	Air
	Priority					
	1	2	3	4	5	6
Metals						
Arsenic (As)	X	X	X	X	X	X
Lead (Pb)	X	X	X	X	X	X
Chromium (Cr)	X	X	X	X	X	–
Cadmium (Cd)	X	X	X	X	X	–
Copper (Cu)	X	X	X	X	X	–
Zinc (Zn)	X	X	X	X	X	–
Volatile Organic Compounds						
1,1,1-Trichloroethane (1,1,1-TCA)	X	X	X	X	X	X
Trichloroethene (TCE)	X	X	X	X	X	X
Tetrachloroethene (PCE)	X	X	X	X	X	X
Methylene chloride (CH_2Cl_2)	X	X	X	X	X	X
Benzene	X	X	–	X	X	X
Toluene	X	X	–	X	X	–
Total xylenes	X	X	–	X	X	–
Ethylbenzene	X	X	–	X	X	–
Vinyl chloride	–	X	–	–	–	X
Semivolatile Organic Compounds						
Pentachlorophenol (PCP)	X	X	X	X	X	X
Polycyclic aromatic hydrocarbons (PAH)	X	X	X	X	X	X
Polychlorinated biphenyls (PCBs)	X	X	X	X	–	–
Pesticides						
DDE, DDD, DDT	X	–	X	X	X	–
Hexachlorocyclohexane (HCH) isomers (including lindane)						
Ethylene dibromide (EDB)	X	X	–	X	X	–
Dioxin						
2,3,7,8-TCDD	X	X	X	–	–	–

- **Step 2 - Data Quality Review:** The quality of data sets that pass preliminary screening is reviewed based on available QA data and discussions with appropriate QA personnel.

The level of effort applied to data set identification and collection has been commensurate with the priorities set by Ecology. For example, a great deal of effort went into the identification, collection, and evaluation of groundwater data sets, and a relatively minor amount of effort went into the identification of air data sets. However, the quantity and quality of the data sets identified is not necessarily in keeping with the priorities established by Ecology because Ecology's priorities are not necessarily those of the institutions or agencies that generated the data.

Additional constraints to the data collection process developed during the course of the project. For some media there are no comprehensive data sets (e.g., freshwater sediments). For some chemicals of interest identified by Ecology, no data have been identified. In other cases, the only data set for a particular chemical in a particular medium did not meet QA criteria (e.g., arsenic and chromium in soil). Where no data are available from Washington state studies, selected data from nationwide studies are presented. Because of resource constraints, it was decided that no attempt would be made to review individual Superfund site studies to obtain associated background data. A number of ongoing studies are identified that will provide valuable information on background concentrations when they are completed.

1.4.2 Data Quality Review

Data quality has been evaluated by screening the QA documentation provided with each report and by using telephone contacts to supplement and fill in the necessary missing elements. QA summaries of individual studies are provided in the appropriate section for each medium. Validation of the data is based upon an evaluation of sample collection and handling techniques (along with holding times), QA samples (e.g., replicates, blanks), analytical methods, and detection limits. Validation criteria are based on standardized protocols to the extent possible [e.g., the U.S. Environmental Protection Agency (EPA) Contract Laboratory Program, the Puget Sound Estuary Program]. Overall acceptability of each study is based on the judgment of the QA reviewer because of the varied methods and ages of the studies. The data review was not rigorous, in part because detailed documentation was not available. Several aspects of the QA review could have exceeded established criteria without disqualification of the particular study.

Specific QA information of interest included precision of replicate samples, calibration of analytical instruments, recovery of surrogate standards, recovery of matrix spikes, and detection of analytes in method blanks. Generally, one or more of these items is missing from all data sets.

1.4.3 General Characteristics of Background Data

Quantification limits constrain the measurement of numerous chemicals of interest in many background samples. Quantification limits are discussed in a separate report (PTI 1989). In most media, metals are naturally present at levels that are detectable with conventional analytical techniques. Some organic chemicals occur naturally and are detectable in selected media [e.g., polycyclic aromatic hydrocarbons (PAH) in soil]. However, most organic chemicals, particularly synthetic organic chemicals, are not detectable in background samples by conventional techniques.

1.4.4 Statistical Analysis

It is important to determine the statistical distribution of data to characterize the central tendency and variability of background concentrations. Data sets were evaluated in two ways: 1) all data were analyzed and each undetected value was treated as the detection limit value, and 2) data for undetected values were excluded from the analysis. For each medium, Washington state chemical data were analyzed using the Kolmogorov-Smirnov (K-S) test to examine whether the data distribution is normal, or more specifically, if the data distribution can be distinguished from an ideal normal distribution at a specified level of significance.

Because the chemical data are generally not found to be normally distributed, the possibility that background concentration data are log-normally distributed was also examined. Thus, the K-S test for normality was also performed on log-transformed data. For each chemical, the following descriptive statistics are reported: detection frequency, range, mean, median, and representative percentile values (10th, 25th, 75th, and 90th). Standard deviations, skewness, and kurtosis were also calculated but are not presented herein.

With few exceptions, the data were not normally or log-normally distributed. In such areas, the mean and standard deviation are of limited value as description statistics. The median and other percentile distributions provide more representative descriptions in these asymmetric distributions.

1.5 REPORT ORGANIZATION

The next seven sections address the background concentrations of individual categories of media. Groundwater, soil, seawater, air, surface freshwater, and freshwater sediments are addressed in Sections 2, 3, 4, 5, 6, and 7, respectively. Marine sediments (Section 8) will be submitted separately.

2. GROUNDWATER

Background concentrations of selected chemicals in Washington state groundwater are presented in this section.

2.1 APPLICABLE STUDIES AND DATA SETS

Data sets have been obtained from the following sources: 1) U.S. Geological Survey (USGS); 2) Ecology's Groundwater Management Area studies for Washington state; 3) Washington Department of Social and Health Services (DSHS); 4) Spokane Groundwater Sampling Study; and 5) EPA studies of pesticides in Washington state.

The USGS has published five regional studies of groundwater quality in Washington state (Ebbert 1984, Turney 1985, Turney 1986a, Turney 1986b, and Ebbert and Payne 1985). The studies were created to assist Ecology with monitoring contamination in groundwaters of principal aquifers. The regional studies generally include data for the inorganic constituents of interest. These studies provide excellent geographical representation of the state for concentrations of metals. The USGS study of Clark County water quality (Wagner 1989) was conducted under a program initiated by Ecology in 1985 to characterize background concentrations of selected pollutants in areas of important groundwater reserves. This data set provides data for almost all of the chemicals of interest identified in Table 1. This ongoing study will eventually provide good geographical coverage of nearly all of the chemicals of interest in Washington state.

The DSHS is responsible for assuring residents of the state of Washington that drinking water meets federal drinking water requirements. Extensive geographical coverage of metal concentrations in drinking water is available (monitoring was started in 1977). A program for analysis of volatile organic compounds (VOC) was initiated in 1988. These data should soon be available. The DSHS has also investigated ethylene dibromide (EDB) contamination in western Washington areas where berries are grown commercially (DSHS 1985). In addition, the EPA has put out a nationwide study of pesticides (Williams et al. 1988) summarizing regional studies in western Washington.

Spokane County has monitored water quality in the Spokane aquifer since 1984. As a sole source aquifer, it merits special attention under the Clean Water Act (Moody et al. 1986). VOC, phenol, and metal data are currently provided. Pesticide data will be available soon.

All of the studies cited above have been screened for QA. The data review was based on QA data provided by the laboratories and additional QA information obtained by telephone contacts. Data reviewers assessed sample collection techniques (including storage and handling times), laboratory quality assurance/quality control (QA/QC), analytical methods employed, and detection limits to determine the usability of the data sets. Table 2 summarizes the status of the key types of information used to assess data quality. Sample sets from areas of known contamination have been avoided because the study goal is to determine background levels of contaminants. The DSHS data set was not used, as the detection limits are fairly high and the values are above lower levels of more extensive USGS studies.

2.2 CHEMICAL CONCENTRATION RANGES AND DISTRIBUTIONS

The results of the statistical analysis of the groundwater data are summarized in Table 3 (including undetected values as detection limits) and Table 4 (excluding undetected values). All of the analytes show non-normal distributions in groundwater by the K-S test for normality based on untransformed and log-transformed data. Because of the skewed nature of the data, the data are presented in terms of detection frequency, range, mean, median, and several percentiles of the data (10th, 25th, 75th, and 90th).

VOC data have been obtained for 20 sites in Clark County. Most of the data are below the detection limits. Of the chemicals reported in the 20 samples from Clark County, 1,1,1-trichloroethane has the highest frequency of detection (three detected values). Methylene chloride, vinyl chloride, ethyl benzene, and xylenes were not detected in any samples.

Pesticides are synthetic compounds and are not expected to be present in pristine areas. Ethylene dibromide is the only compound reported by DSHS (1985) and the only pesticide detected in the background studies compiled here. It was detected in 34 of 131 samples. None of the chemicals analyzed in the DDT or HCH families were detected. No data for 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) were found for groundwater in the state of Washington.

Semivolatile organic data are reported in only one study (Wagner 1989). No PAH were found (however, only lower molecular weight compounds were analyzed). Polychlorinated biphenyls (PCBs) were also undetected. Pentachlorophenol (PCP) data were not available for groundwater.

TABLE 2. DATA REVIEW SUMMARY FOR GROUNDWATER

Study		Chemical Groups Included	Study Acceptable?	# of Samples	Sample Collection	Sample Handling/ Storage	QA/QC	Analytical Methods	Limits of Detection
Williams et al.	1988	Pesticides	Yes	96	A[a]	A	A	A	A
Turney	1985	Metals	Yes	116	A	A	A	A	A
Turney	1986a	Metals	Yes	21	A	A	A	A	A
Ebbert and Payne	1985	Metals	Yes	27	A	A	A	A	A
Ebbert	1984	Metals	Yes	22	A	A	A	A	A
Turney	1986b	Metals	Yes	56	A	A	A	A	A
Wagner	1989	Metals, VOC semivolatiles, & pesticides	Yes	20	A	A	A	A	A
Ecology	1985	EDB	No	4					
County of Spokane	1988	Metals	Yes (metals) No (organics)	160	A	A	A/U[b]	A/U	A/U
Department of Social and Health Services	1985	EDB	Yes	131	N[c]	N	N	N	A
Ebbert et al.	1987	Metals	Yes	35	A	A	A	A	A

[a] A = Acceptable

[b] U = Unacceptable

[c] N = Not available

TABLE 3. GROUNDWATER DATA CHARACTERISTICS[a] (ALL DATA)

Chemical	Frequency of Detection	Range	Mean	Median	Percentile 10	25	75	90
Metals								
As	200/264	<1-100	3.9	2	1	1	5	8
Pb	80/322	<1-85	5.2	5	1	1	10	10
Cr	47/319	<1-35	7.6	10	1	1	10	10
Cd	29/350	<1-10	1.2	1	0.5	1	1	2
Cu	170/349	<1-1,700	37	10	1	2	10	20
Zn	246/354	<3-2,300	82	10	3	10	40	160
Volatile Organic Compounds								
1,1,1-TCA	1/3	<0.2-6.8	2.4	0.2	0.2	0.2	6.8	6.8
TCE	0/18	<0.2	–	–	–	–	–	–
PCE	2/18	<0.2-1.4	0.3	0.2	0.2	0.2	0.2	0.3
CH_2Cl_2	0/3	<0.2	–	–	–	–	–	–
Benzene	1/18	<0.2-0.2	0.2	0.2	0.2	0.2	0.2	0.2
Toluene	1/18	<0.2-0.5	0.2	0.2	0.2	0.2	0.2	0.2
Total xylenes	0/18	<0.2	–	–	–	–	–	–
Ethylbenzene	4/18	<0.2-0.2	0.2	0.2	0.2	0.2	0.2	0.2
Vinyl chloride	0/18	<0.2	–	–	–	–	–	–
Semivolatile Organic Compounds								
PCP	–	–	–	–	–	–	–	–
PAH	0/20	<5	–	–	–	–	–	–
PCBs	0/20	<0.2	–	–	–	–	–	–
Pesticides								
DDE	0/20	<0.2	–	–	–	–	–	–
DDD	0/20	<0.2	–	–	–	–	–	–
DDT	0/20	<0.2	–	–	–	–	–	–
HCH isomers	0/20	<0.2	–	–	–	–	–	–
EDB	36/130	<0.01-5.7	0.2	0.01	0.01	0.01	0.06	0.4
Dioxin								
2,3,7,8-TCDD	–	–	–	–	–	–	–	–

[a] All values for metals and organic chemicals are in units of µg/L.

TABLE 4. GROUNDWATER DATA CHARACTERISTICS[a] (OMITTING DATA BELOW DETECTION LIMITS)

Chemical	N[b]	Range	Mean	Median	Percentile 10	25	75	90
Metals								
As	200	1.0-100	3.9	3	1	1	6	9
Pb	80	1.0-22	5.2	2	1	1	3	5
Cr	47	1.0-20	7.6	10	1	5	10	10
Cd	29	1.0-10	1.2	1	1	1	2	3
Cu	170	1.0-1,700	37	4	1	1	14	50
Zn	264	3.0-2,300	82	20	6	10	70	250
Volatile Organic Compounds								
1,1,1-TCA	1	6.8	--	--	--	--	--	--
TCE	0	--	--	--	--	--	--	--
PCE	2	0.3-1.4	0.8	0.3	0.3	0.3	1.4	1.4
CH_2Cl_2	0	--	--	--	--	--	--	--
Benzene	1	0.2	--	--	--	--	--	--
Toluene	1	0.5	--	--	--	--	--	--
Total xylenes	0	--	--	--	--	--	--	--
Ethylbenzene	4	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Vinyl chloride	0	--	--	--	--	--	--	--
Semivolatile Organic Compounds								
PCP	--	--	--	--	--	--	--	--
PAH (L)	0	--	--	--	--	--	--	--
PCBs	0	--	--	--	--	--	--	--
Pesticides								
DDE	0	--	--	--	--	--	--	--
DDD	0	--	--	--	--	--	--	--
DDT	0	--	--	--	--	--	--	--
HCH isomers	0	--	--	--	--	--	--	--
EDB	36	0.18-5.7	0.8	0.3	0.06	0.1	0.7	2.3
Dioxin								
2,3,7,8-TCDD	--	--	--	--	--	--	--	--

[a] All values for metals and organic chemicals are in units of $\mu g/L$.

[b] N = Number of samples above detection limits.

Overall, the data selected to represent metal concentrations in Washington state groundwater have broad geographical coverage. The data for organic chemicals are of limited geographic distribution. No groundwater data are identified for PCP and 2,3,7,8-TCDD. All measurements for PAH, trichloroethene (TCE), dichloromethane (CH_2Cl_2), DDT, DDD, DDE, xylenes, vinyl chloride, lindane (gamma-HCH), and PCBs are below detection limits.

2.3 ADDITIONAL RELEVANT STUDIES

A number of ongoing projects will contribute valuable information about the background concentrations of selected chemicals in groundwater. These projects are summarized in Table 5. Of these, the Groundwater Management Area study supported by Ecology is the most comprehensive. As noted above, this study addresses background concentrations of key pollutants in areas of important groundwater reserves. However, only the Clark County area results were available at the time of this report.

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TABLE 5. GROUNDWATER STUDIES

Name	Responsible Organization	Pollutants Sampled	Special Areas	When Available
Groundwater management areas	Ecology	Varies	Clover Chambers, Pierce County Gig Harbor, Pierce County Island County-Whidbey South King County Vashon & Maury Islands Bear Creek, Redmond Issaquah Creek Valley Kitsap County Clark County North Thurston Deer Park, Spokane County Methow Basin, Okanogan	6-12 months
National pesticide survey	EPA	Pesticides	Western Washington	1-2 years
Argonne Road study	USGS, Ecology, DSHS	Solvents	Argonne Road (Spokane)	Soon
Exceedance values	DSHS	Varies	Statewide	6-8 weeks
Study	Ecology	Pesticides	Whatcom, Franklin, Yakima Counties	2-6 months
Study	USGS	Pesticides	Benton, Franklin Counties	1 year
Study	Spokane County	Pesticides	Spokane County	Soon
Study	Yakima Tribes	Unknown	Toppenish Creek Basin	Soon

3. SOIL

Background concentration of selected chemicals in Washington state and nationwide soils are presented in this section.

3.1 APPLICABLE STUDIES AND DATA SETS

Soil data have been obtained from three major sources: 1) the U.S. Department of Agriculture (USDA) 2) USGS, and 3) Ecology. The major USDA study recommended by USDA contacts (Dr. R. Chaney, 9 February 1989) characterizes background concentrations of selected trace elements (cadmium, copper, lead, and zinc) and pH in unpolluted agricultural soils throughout the nation (Holmgren et al. 1988). This study contains data for 12 sites throughout Washington state. The study was initiated in 1979 in response to rising concerns about the human health effects of trace metals in food crops. The goal of this study was to create a database on background levels that could be used as a reference point to identify potentially polluted crops and soils.

A previous USDA study of pesticide residues in soil (Stevens et al. 1970) focuses on areas of regular pesticide application, and provides a useful indication of ambient pesticide concentrations in areas of pesticide use during the period of study (1965 to 1967), but is not representative of current conditions. Selected reference areas (i.e., limited use areas) provide a better indication of background but are still dated.

The major Ecology soil study completed at the time of this report characterizes surface soil contamination at a fertilizer, pesticide, and herbicide facility in Othello, Washington. This site, which was contaminated, does not provide a good indication of background concentrations of pesticides, other organic chemicals, or metals.

Two USGS studies (Shacklette and Boerngen 1984; Ebens and Shacklette 1982) characterize the concentrations of a large number of elements (47 and 59, respectively) over a large portion of the United States. Although these studies contain little or no data for the state of Washington, they provide useful general references for metal concentrations in soil.

The results of the abbreviated QA review are shown in Table 6. Only the more recent USDA study (Holmgren et al. 1988) is included in the Washington state database. However, results from some of the other studies are included in the data evaluation for comparison purposes.

3.2 CHEMICAL CONCENTRATIONS AND RANGES

The results of the statistical analysis of the data are summarized in Table 7. All of the analytes except zinc show a non-normal distribution in soils (K-S test; $P>0.05$). Log transformations of the data were also unsuccessful in normalizing the data when analyzed by the K-S test. Because of the skewed nature of the data, the data are presented in terms of detection frequency, range, mean, median, and several percentiles (10th, 25th, 75th, and 90th). Although zinc is normally distributed according to the K-S test, zinc data are presented in the same manner as the other metals for comparison purposes.

The soil data set contains several data gaps. No studies from Washington state were found for VOC, semivolatile organic compounds, or pesticides (except for Stevens et al. 1970). Chromium in soils also represents a data gap. For chemicals where Washington state data are limited or absent, studies from other areas (preferably broad geographical areas) are summarized to provide general information (i.e., median, range) on background concentrations. The results of the USGS soil study (Shacklette and Boerngen 1984) are presented in Table 8 and compared to results from the Washington state data sets.

3.3 ADDITIONAL RELEVANT STUDIES

Ecology, in cooperation with USGS, is currently conducting an evaluation of four extraction techniques [two total digestion extractions, the Extraction Procedure Toxicity (EP Tox) test, and the ASTM water leaching test] to characterize the concentrations of metals in the soils of south King County. After the present study is completed, a statewide study on metals in soils will be conducted. An ongoing study of background concentrations at Hanford may also contain useful background data.

It may be possible to obtain additional soil data through local county soil services. A review of Superfund studies would also yield additional data on background concentrations of contaminants in soil. The studies on the application of sludge to forest soils by scientists at the University of Washington and Washington State University may also contain useful soil data. None of these data sources have been pursued.

TABLE 6. DATA REVIEW SUMMARY FOR SOIL

Study		Chemical Groups Included	Study Acceptable?	# of Samples	Sample Collection	Sample Handling/ Storage	QA/QC	Analytical Methods	Limits of Detection
Norton	1988	Metals, pesticides	No[d]	9	A[a]	A	A	A	A
Ebens, & Shacklette	1982	Metals	No	Means & ranges only	N[b]	N	N	N	N
Shacklette, & Boerngen	1984	Metals	No	26	A	N	N	U[c]	A
Holmgren et al.	1988	Metals	Yes	122	A	A	A	A	A
Stevens et al.	1970	As & DDT	Yes	10	A	U	N	A	A

[a] A = Acceptable

[b] N = Not available

[c] U = Unacceptable

[d] Study conducted at a contaminated site.

TABLE 7. SOIL DATA CHARACTERISTICS[a]

Chemical	Frequency of Detection	Range	Mean	Median	Percentile 10	25	75	90
Metals								
As	–	–	–	–	–	–	–	
Pb	119/119	4.0-23	9.1	8.0	6.0	7.0	9.0	17
Cr	–	–	–	–	–	–	–	–
Cd	119/119	$0.8x10^{-4}$-$5.5x10^{-4}$	$2.0x10^{-4}$	$1.8x10^{-4}$	$1.3x10^{-4}$	$1.5x10^{-4}$	$2.1x10^{-4}$	$2.8x10^{-4}$
Cu	119/119	1.0-86	28	26	17	23	32	38
Zn	119/119	26-109	68	66	51	56	78	88
Volatile Organic Compounds								
1,1,1-TCA	–	–	–	–	–	–	–	–
TCE	–	–	–	–	–	–	–	–
PCE	–	–	–	–	–	–	–	–
CH_2Cl_2	–	–	–	–	–	–	–	–
Benzene	–	–	–	–	–	–	–	–
Toluene	–	–	–	–	–	–	–	–
Total xylenes	–	–	–	–	–	–	–	–
Ethylbenzene	–	–	–	–	–	–	–	–
Vinyl chloride	–	–	–	–	–	–	–	–
Semivolatile Organic Compounds								
PCP	–	–	–	–	–	–	–	–
PAH	–	–	–	–	–	–	–	–
PCBs	–	–	–	–	–	–	–	–
Pesticides								
DDE	–	–	–	–	–	–	–	–
DDD	–	–	–	–	–	–	–	–
DDT	–	–	–	–	–	–	–	–
EDB	–	–	–	–	–	–	–	–
Dioxin								
2,3,7,8-TCDD	–	–	–	–	–	–	–	–

[a] All values for metals are in units of mg/kg and all values for organics are in units of $\mu g/kg$.

TABLE 8. CHEMICAL CONCENTRATIONS IN SOIL

	Washington State Summary With All Data (mg/kg)		Shacklett and Boerngen (1984) (mg/kg)	
Chemical	Mean	Range	Mean	Range
Arsenic	--	--	7.2	<0.1-97
Lead	9.1	4-23	19	<10-700
Chromium	--	--	54	1-2,000
Cadmium	2.0×10^{-4}	0.80×10^{-4}-5.5×10^{-4}	--	--
Copper	28	1-86	25	<1-700
Zinc	68	26-109	60	<5-2,900

4. SEAWATER

Background concentration of selected chemicals in Puget Sound and the world ocean are presented in this section.

4.1 APPLICABLE STUDIES AND DATA SETS

Data sets have been identified to obtain existing information for the categorization of background contaminant concentrations in Washington state seawater. The only relevant data set available is a National Oceanographic and Atmospheric Administration (NOAA) study (Paulson et al. 1988a). This study was conducted in order to determine the sources and sinks of lead, copper, zinc, and manganese in Puget Sound.

The NOAA study was screened for QA and found acceptable. Data reviewers assessed sample collection techniques (including storage and handling times), laboratory QA/QC, analytical methods employed, and detection limits to determine usability of the data sets. Sample sets from areas of known contamination have been avoided because the study goal is to determine background levels of contaminants. The results of the data quality review are summarized in Table 9.

4.2 CHEMICAL CONCENTRATION RANGES AND DISTRIBUTIONS

The results of the statistical analysis of the data are summarized in Table 10. All four of the metals show normal distributions by the K-S test ($P>0.05$). However, the frequency distributions do not appear normal on visual examination. The K-S test may provide misleading results because of the small number of data points. The statistical data presented in Table 10 include detection frequency, range, mean, median, and several percentiles (10th, 25th, 75th, and 90th). All of the metals measured are above the detection limit.

Comparison of the metal concentrations measured by Paulson et al. (1988a) in Puget Sound with others in oceans worldwide (summarized in Martin and Whitfield, 1983) provides a useful indication of typical levels of metals in seawater (Table 11).

TABLE 9. DATA REVIEW SUMMARY FOR SEAWATER

Study		Chemical Groups Included	Study Acceptable?	# of Samples	Sample Collection	Sample Handling/ Storage	QA/QC	Analytical Methods	Detection Limits
Paulson et al.	1988a	Metals	Yes	7	A[a]	A	A	A	A
Paulson et al.	1988b	Metals	Yes	NR[b]	A	A	A	A	A

[a] A = Acceptable

[b] NR = Not reported

TABLE 10. SEAWATER DATA CHARACTERISTICS[a]

Chemical	Frequency of Detection	Range	Mean	Median	Percentile 10	25	75	90
Metals								
As	–	–	–	–	–	–	–	–
Pb	7/7	0.015-0.13	0.041	0.028	0.015	0.019	0.040	0.13
Cr	–	–	–	–	–	–	–	–
Cd	–	–	–	–	–	–	–	–
Cu	7/7	0.14-1.7	0.59	0.39	0.14	0.30	0.65	1.7
Zn	7/7	0.19-3.9	1.3	0.79	0.19	0.37	2.2	3.9
Volatile Organic Compounds								
1,1,1-TCA	–	–	–	–	–	–	–	–
TCE	–	–	–	–	–	–	–	–
PCE	–	–	–	–	–	–	–	–
CH_2Cl_2	–	–	–	–	–	–	–	–
Benzene	–	–	–	–	–	–	–	–
Toluene	–	–	–	–	–	–	–	–
Total xylenes	–	–	–	–	–	–	–	–
Ethylbenzene	–	–	–	–	–	–	–	–
Vinyl chloride	–	–	–	–	–	–	–	–
Semivolatile Organic Compounds								
PCP	–	–	–	–	–	–	–	–
PAH	–	–	–	–	–	–	–	–
PCBs	–	–	–	–	–	–	–	–
Pesticides								
DDE	–	–	–	–	–	–	–	–
DDD	–	–	–	–	–	–	–	–
DDT	–	–	–	–	–	–	–	–
HCH isomers	–	–	–	–	–	–	–	–
EDB	–	–	–	–	–	–	–	–
Dioxin								
2,3,7,8-TCDD	–	–	–	–	–	–	–	–

[a] All values for metals and organic chemicals are in units of 7 μg/L.

TABLE 11. CHEMICAL CONCENTRATIONS IN SEAWATER

Chemical	Washington State Summary With All Data		Martin and Whitfield (1983)
	Mean (μg/L)	Range (μg/L)	Mean (mg/L)
Arsenic	--	--	1.5
Lead	0.041	0.015-0.13	0.003
Chromium	--	--	0.01
Cadmium	0.59	0.14-1.7	0.1
Copper	--	--	0.3
Zinc	1.3	0.19-3.9	0.1

4.3 ADDITIONAL RELEVANT STUDIES

Limited effort went into the identification and collection of background concentrations of chemicals in seawater because it is a low-priority medium as determined by Ecology. Even in the relatively contaminated waters of urban bays, it is likely that metals and organic chemicals of interest identified by Ecology are present at levels well below the quantification limits obtained by conventional analytical methods. No additional studies have been identified, and no further data gathering is recommended at this time.

5. AIR

Background concentrations of selected chemicals in Washington state air are presented in this section.

5.1 APPLICABLE STUDIES AND DATA SETS

Data have been obtained from four sources: 1) the Puget Sound Air Pollution Control Agency (PSAPCA), 2) the Department of Civil Engineering at University of Washington, 3) EPA, and 4) a summary review of metals in airborne particulates performed by Canadian researchers.

The PSAPCA reports contain data for arsenic and lead from King, Kitsap, Pierce, and Snohomish Counties for 1985-1987 (PSAPCA 1986, 1987, 1988). These data sets address ambient levels of arsenic and lead in metropolitan areas and are included in the Washington state database.

Larson et al. (1988) conducted a study to assess the cancer risk associated with urban air contaminants for PSAPCA. Their report contains extensive metal and PAH data on air collected in north Seattle. The PAH compounds measured include naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, chrysene, benzo(b+k)fluoranthenes, benzo(a)pyrene, indeno(1,2,3-c,d)pyrene, dibenz(a,h)anthracene, and benzo(g,h,i)perylene. These data were entered in the Washington state database because air was designated a low-priority medium by Ecology, and the size and content of the data set did not justify the resource requirements for database entry. Consequently, these data are presented in the summary format that was provided in Larson et al. (1988).

VOC air data were obtained from an EPA study (U.S. EPA 1988) that included data from Canada and the United States as contributions to the Interim Air Toxic Data Base. No data from Washington state were included in the report. Data from Vancouver, British Columbia are presented here because of the proximity to Washington state and because a comprehensive summary of all data was not included in the report. The EPA report provides only summary data by location (i.e., means and maximum concentrations) and was not included in the Washington state database.

The review study by Canadian researchers (Schroeder et al. 1987) summarizes metals data from hundreds of studies worldwide. The report distinguishes remote, urban, and rural concentrations of metals in atmospheric particulate material and provides a comprehensive overview of air metals concentrations.

Only two studies sponsored by PSAPCA (i.e., PSAPCA 1986, 1987, 1988; Larson 1988) have been screened in a QA review. The data review was based on QA data provided by the laboratories and additional QA information obtained by telephone contacts. Data reviewers assessed sample collection techniques (including storage and handling times), laboratory QA, analytical methods employed, and detection limits to determine if the data should be included in the Washington state database. Table 12 summarizes the status of the key types of information used to assess data quality.

5.2 CHEMICAL CONCENTRATION RANGES AND DISTRIBUTIONS

The results of the statistical analysis of the data (PSAPCA 1986, 1987, 1988 only) are summarized in Table 13 (including undetected values as detection limits) and Table 14 (excluding undetected values). The metal concentrations in air show a non-normal distribution by the K-S test for normality for both untransformed and log-transformed data. Because of the skewed nature of the data, the statistical summary includes detection frequency, range, mean, median, and several percentiles (10th, 25th, 75th, and 90th).

The organic data and associated statistics presented in Tables 13 and 14 are from the summaries given in the respective reports. The individual PAH reported in Larson et al. (1988) are summarized by giving range, mean, and median from Lake Forest Park during daylight hours. Frequency of detection was not reported. However, the lower quantification limit was provided and is shown in Table 13. Data from this study are not included in Table 14 because detection frequency was not known. Based on comparison of the lower quantification limit with the range of reported values, it is likely that most of the data exceeded detection limits. VOC are summarized by giving the mean and the maximum concentration measured in Vancouver, British Columbia (U.S. EPA 1988). Only numbers of observations were reported. It is assumed that an "observation" is represented by a detected value. No data were available for PCP, CH_2Cl_2, 1,1,1-TCA, and vinyl chloride.

The data from these three sets cover only metropolitan regions. Rural areas would generally be expected to have lower levels of contaminants. This trend is illustrated for metals in Table 15. Arsenic and lead data from the Washington state studies are compared to the worldwide values summarized in Schroeder et al. (1987).

TABLE 12. DATA REVIEW SUMMARY FOR AIR

Study		Chemical Groups Included	Study Acceptable?	# of Samples	Sample Collection	Sample Handling/ Storage	QA/QC	Analytical Methods	Limits of Detection
Larson et al.	1988	Metals, PAH	Yes	72	A	A	A	A	A
PSAPCA	1986	As, Pb	Yes	56	A	A	A	A	A
PSAPCA	1987	As, Pb	Yes	43	A	A	A	A	A
PSAPCA	1988	As, Pb	Yes	39	A	A	A	A	A

TABLE 13. AIR DATA CHARACTERISTICS[a] (USING ALL DATA)

Chemical	Frequency[b] of Detection or LQL[c]	Range	Mean	Median	Percentile 10	25	75	90
Metals								
As	16/21	<10-770	90	10	10	10	80	100
Pb	129/129	<20-11,000	290	130	40	70	250	430
Volatile Organic Compounds[d]								
1,1,1-TCA	–	–	–	–	–	–	–	–
TCE	9/9	0.0034[e]	0.0010	–	–	–	–	–
PCE	9/9	0.0017[e]	0.0012	–	–	–	–	–
CH_2Cl_2	–	–	–	–	–	–	–	–
Benzene	9/9	0.025[e]	0.0095	–	–	–	–	–
Vinyl chloride	–	–	–	–	–	–	–	–
Semivolatile Organic Compounds								
PCP		–	–	–	–	–	–	–
PAH								
Naphthalene	0.90[c]	0.45-1.9	0.73	0.70	–	–	–	–
Acenaphthylene	1.11[c]	0.55-5.5	1.09	0.55	–	–	–	–
Acenaphthene	1.55[c]	0.77-1.09	0.79	0.77	–	–	–	–
Fluorene	1.38[c]	0.69-1.05	0.71	0.64	–	–	–	–
Phenanthrene	0.90[c]	0.17-2.0	0.65	0.53	–	–	–	–
Anthracene	1.32[c]	0.41-2.2	0.68	0.61	–	–	–	–
Fluoranthene	0.75[c]	0.50-4.8	1.8	1.6	–	–	–	–
Pyrene	0.99[c]	0.49-7.3	2.5	2.4	–	–	–	–
Chrysene	1.45[c]	0.72-15	5.6	5.4	–	–	–	–
Benzo(b+k)fluoranthene	1.00[c]	0.5-23	5.3	5.4	–	–	–	–
Benzo(a)pyrene	1.50[c]	0.75-17	4.5	4.1	–	–	–	–
Indeno(1,2,3-c,d) pyrene	2.30[c]	0.98-11	4.5	4.9	–	–	–	–
Dibenz(a,h)anthracene	5.35[c]	0.98-8.3	3.1	2.7	–	–	–	–
Benzo(g,h,i)perylene	2.22[c]	0.98-15	6.3	8.4	–	–	–	–

[a] All values for metals and organics are in units of ng/m^3.

[b] For volatile organics, only number of observations were reported.

[c] LQL = Lower quantification limit; frequency of detection was not provided for these chemicals.

[d] VOC data from U.S. EPA (1988). Only number of observations, mean, and maximum concentration were reported.

[e] Maximum values only were reported for VOC.

TABLE 14. AIR DATA CHARACTERISTICS[a] (OMITTING DATA BELOW DETECTION LIMITS)

Chemical	N[b]	Range	Mean	Median	Percentile 10	25	75	90
Metals								
As	16	0.01-0.77	0.11	0.01	0.01	0.09	0.49	--
Pb	129	20-11,000	290	130	40	70	250	430
Volatile Organic Compounds								
1,1,1-TCA	--	--	--	--	--	--	--	--
TCE	9/9	0.0034	0.0010	--	--	--	--	--
PCE	9/9	0.0017	0.0012	--	--	--	--	--
CH_2Cl_2	--	--	--	--	--	--	--	--
Benzene	9/9	0.025	0.0095	--	--	--	--	--
Vinyl chloride	--	--	--	--	--	--	--	--
Semivolatile Organic Compounds								
PCP	--	--	--	--	--	--	--	--
PAH	--	--	--	--	--	--	--	--

[a] All values for metals and organic chemicals are in units of $\mu g/L$.

[b] N = Number of samples above detection limits. For volatile organics, only number of observations were reported.

TABLE 15. METAL CONCENTRATIONS IN AIR[a]

Location	Arsenic	Lead
Washington state data[b]		
(all data)	<10-770	<20-11,000
Global summary data[c]		
Remote	0.007-1.9	0.007-64
Rural	1.0-2.8	2-1,700
Urban		
Canada	7.7-626	353-3,416
U.S.A.	2-2,320	30-96,270
Europe	5-330	10-9,000
Other	20-85	1.3-11,020

[a] Concentrations in units of ng/m^3.

[b] PSAPCA 1986, 1987, 1988.

[c] Schroeder et al. (1987).

5.3 ADDITIONAL RELEVANT STUDIES

Limited effort went into the identification and collection of background concentrations of chemicals in air because it is a low-priority medium as determined by Ecology. Dr. Tim Larson at the University of Washington (23 January 1989, personal communication) suggested the following data sources:

- Hal Westberg at Washington State University specializes in volatile organic chemicals in air and may provide additional data in this area.

- Rick Vong (1988 publication in the Journal of Geophysical Research) has measured metal concentrations in air on the western side of the Olympic peninsula. These data will provide reference values for pristine conditions.

- The provincial government of British Columbia, Canada has extensively studied chemical concentrations in air.

- EPA has conducted a number of urban airshed studies. These data would provide a more complete picture of ambient concentrations in urban air.

6. SURFACE FRESHWATER

Background concentrations of selected chemicals in Washington state surface freshwaters are presented in this section.

6.1 APPLICABLE STUDIES AND DATA SETS

Data sets for surface freshwater have been obtained from the following sources: 1) USGS, 2) Ecology, 3) Municipality of Metropolitan Seattle (Metro), and 4) a masters thesis submitted to the University of Washington Department of Civil Engineering.

The USGS National Stream Quality Network (NASQAN) database (Wagner 1989) provides the most geographically comprehensive information on metal concentrations in the streams of Washington state. Monitoring data from 12 stations throughout the state, covering the time period between 1980 and 1988, were included in the Washington state freshwater database. The USGS also conducted a study on the water quality of the lower Puyallup River (Ebbert et al. 1987) . The valley is of importance because the area supports the residential, commercial, industrial, and agricultural activities of the Puyallup Indian Tribe. The data set includes concentrations of metals and VOC from 16 sites in the valley.

Three studies were conducted by Ecology. Johnson et al. (1986) analyzed metals, total DDT, and PCB in Yakima River waters to determine the persistence of DDT and PCB in that area. Johnson et al. (1988) initiated a study to determine the influence of the world's largest zinc refinery (Cominco Limited) on the levels of metals in Lake Roosevelt, Washington's largest reservoir. Yake et al. (1986) analyzed metals, PAH [including benzo(a)pyrene], and PCB in water from Lake Union and Chester Morse Reservoir while testing the triad approach to sediment analysis (bioassays, benthic infauna analyses, and chemical analyses).

Metro published a baseline study of Lake Union (Tomlinson et al. 1977), in which the level of metal contamination was assessed to evaluate water quality in Lake Union.

Barnes (1976) determined the levels of metals in waters from Findley Lake, Chester Morse Reservoir, Lake Sammamish, and Lake Washington as part of projects for the EPA and Interna-

tional Biological Program (IBP). This constituted the research portion of his Master of Science program in the Civil Engineering Department at University of Washington.

All of the studies have been screened for QA. The data review was based on QA data provided by the laboratories and additional QA information obtained by telephone contacts. Data reviewers assessed sample collection techniques (including storage and handling times), laboratory QA analytical methods employed, and detection limits to determine the usability of the data sets. Table 16 summarizes the status of the key types of information used to assess data quality. Sample sets from localized areas of known contamination (i.e., in the immediate vicinity of the zinc refinery) have been excluded, because the study goal is to determine background levels of contaminants.

6.2 CHEMICAL CONCENTRATION RANGES AND DISTRIBUTIONS

The results of the statistical analysis of the surface freshwater data are summarized in Table 17 (including undetected values as detection limits) and Table 18 (excluding undetected values). All of the metals showed a non-normal distribution in surface freshwater (K-S test; $P>0.05$). Log transformation of the data were also unsuccessful in normalizing the data when analyzed by the K-S test. Because of the skewed nature of the data, the data are presented in terms of detection frequency, range, mean, median, and several percentiles (10th, 25th, 75th, and 90th).

Organics concentration data were normally distributed according to the K-S test. However, the frequency distributions do not appear normal on visual examination. The K-S test may provide misleading results because of the small number of data points. The test measures the largest deviation from a normal curve as its index. When there are only a few numbers, the deviations from normal are small, and the K-S test gives positive results. The statistical data for organic compounds are therefore presented as above.

Wagner (1989) provides excellent coverage for metals statewide. Few PAH and VOC concentrations were reported for Washington state. No data were available for toluene, xylene, ethylene dibromide, or PCP.

TABLE 16. DATA REVIEW SUMMARY FOR SURFACE FRESHWATER

Study		Chemical Groups Included	Study Acceptable?	# of Samples	Sample Collection	Sample Handling/ Storage	QA/QC	Analytical Methods	Limits of Detection
Wagner	1989	Metals, DDT	Yes	1,311	A[a]	A	A	A	A
Johnson et al.	1988	Metals	Yes	29	A	A	A	A	A
Johnson et al.	1986	Metals, DDT, PCB (1260)	Yes	46	A	A	A	A	A
Johnson and Norton	1988	Metals, BaP[b], PAH	Yes	11	A	A	A	A	A
Yake et al.	1986	Metals, BaP, PAH, PCB	Yes	2	A	A	A	A	A
Ebbert et al.	1987	Metals, VOC	Yes	60	A	A	A	A	A
McGavock et al.	1987	Metals	Yes	64	A	A	A	A	A
Barnes	1976	Metals	Yes	56	A	A	A	A	N[c]
Tomlinson et al.	1977	Metals	Yes	83	A	A	A	A	A

[a] A = Acceptable

[b] Benzo(a)pyrene

[c] N = Not available

TABLE 17. SURFACE FRESHWATER DATA CHARACTERISTICS[a] (USING ALL DATA)

Chemical	Frequency of Detection	Range	Mean	Median	Percentile 10	25	75	90
Metals								
As	530/908	<1.0-18	1.6	1.0	1.0	1.0	2.0	3.0
Pb	828/1,167	<1.0-340	7.0	4.0	1.0	2.0	6.0	11
Cr	123/576	<1.0-40	4.7	1.0	1.0	1.0	10	10
Cd	157/822	<1.0-300	1.8	1.0	1.0	1.0	2.0	2.0
Cu	1,047/1,238	<1.0-460	6.0	3.0	1.0	2.0	5.0	10
Zn	875/1,137	<2.0-480	22	13	3.0	6.0	20	40
Volatile Organic Compounds								
1,1,1-TCA	4/4	1.0-8.0	3.2	1.2	1.0	1.0	2.5	8.0
TCE	3/3	1.0-4.3	2.7	2.7	1.0	1.0	4.3	4.3
PCE	5/5	1.7-16	7.2	4.8	1.7	2.4	11	16
CH_2Cl_2	4/4	1.3-17	9.9	9.4	1.3	1.3	12	17
Benzene	3/3	1.0-3.9	2.3	1.9	1.0	1.0	3.9	3.9
Toluene	--	--	--	--	--	--	--	--
Total xylenes	--	--	--	--	--	--	--	--
Ethylbenzene	2/2	2.7-6.0	4.4	2.7	2.7	2.7	6.0	6.0
Semivolatile Organic Compounds								
PCP	--	--	--	--	--	--	--	--
PAH	0/1	<1	<1	<1	<1	<1	<1	<1
PCB	0/18	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Pesticides								
DDE	6/21	<0.010-0.030	0.013	0.010	0.010	0.010	0.010	0.020
DDD	1/21	<0.010-<0.040	0.019	0.020	0.010	0.020	0.020	0.020
DDT	5/21	<0.020-0.040	0.021	0.020	0.010	0.020	0.020	0.040
EDB	--	--	--	--	--	--	--	--

[a] All values for metals and organic chemicals are in units of $\mu g/L$.

TABLE 18. SURFACE FRESHWATER DATA CHARACTERISTICS[a] (OMITTING DATA BELOW DETECTION LIMITS)

Chemical	N[b]	Range	Mean	Median	Percentile 10	25	75	90
Metals								
As	530	1.0-18	2.0	1.0	1.0	1.0	2.0	4.0
Pb	828	1.0-340	8.6	4.0	1.0	2.0	7.0	13
Cr	123	1.0-40	5.3	3.0	1.0	1.0	10	10
Cd	157	1.0-300	4.6	2.0	1.0	1.0	2.0	5.0
Cu	1,047	1.0-460	6.1	3.0	1.0	2.0	5.0	8.0
Zn	875	2.0-480	25	13	5.0	7.0	24	50
Volatile Organic Compounds								
1,1,1-TCA	4	1.0-8.0	3.2	1.2	1.0	1.0	2.5	8.0
TCE	3	1.0-4.3	2.7	2.7	1.0	1.0	4.3	4.3
PCE	5	1.7-16	7.2	4.8	1.7	2.4	11	16
CH_2Cl_2	4	1.3-17	9.9	11	1.3	1.3	12	17
Benzene	3	1.0-3.9	2.3	1.9	1.0	1.0	3.9	3.9
Toluene	--	--	--	--	--	--	--	--
Total xylenes	--	--	--	--	--	--	--	--
Ethylbenzene	2	2.7-6.0	4.4	2.7	2.7	2.7	6.0	6.0
Semivolatile Organic Compounds								
PCP	--	--	--	--	--	--	--	--
PAH	0	--	--	--	--	--	--	--
PCB	0	--	--	--	--	--	--	--
Pesticides								
DDE	6	0.010-0.030	0.020	0.020	0.010	0.010	0.030	0.030
DDD	1	0.010	0.010	0.010	0.010	0.010	0.010	0.010
DDT	5	0.020-0.040	0.028	0.020	0.020	0.020	0.040	0.040
EDB	--	--	--	--	--	--	--	--

[a] All values for metals and organic chemicals are in units of $\mu g/L$.

[b] N = Number of samples above detection limits.

6.3 ADDITIONAL RELEVANT STUDIES

The ambient monitoring program conducted by Ecology will provide additional information on background concentrations of chemicals in surface freshwater after changes in analytical protocols have been implemented. Currently, no data on organic compounds are available through this program. Metals data have been excluded from the database because of problems with analytical procedures (Hopkins, B., 1 February 1989, personal communication). No other data sets were identified during the course of this task. However, it is likely that EPA has conducted national surveys of contaminants in freshwater. Studies conducted at research institutions would also provide a valuable source of low-level background data.

7. FRESHWATER SEDIMENTS

Background concentrations of selected chemicals in Washington state freshwater sediments are presented in this section.

7.1 APPLICABLE STUDIES AND DATA SETS

Data sets have been obtained from the following sources: 1) USGS, 2) Ecology, 3) Metro, and 4) the Department of Civil Engineering at University of Washington.

The USGS published a study of the sediment and water quality of the lower Puyallup River valley because of its vital importance to the Puyallup Indian Tribe (Ebbert et al. 1987). This valley is of importance because the area supports residential, commercial, industrial, and agricultural pursuits. The data set includes concentrations of metals from 16 sites in the valley.

Four independent studies were conducted by Ecology. Johnson et al. (1988) initiated a study to determine the influence of the world's largest zinc refinery (Cominco Limited) on sediments in Lake Roosevelt, Washington's largest reservoir. Johnson et al. (1986) analyzed sediments from the Yakima River to determine the persistence of DDT and PCB in that area. Johnson and Norton (1988) conducted a screening survey of ports on the lower Columbia River. Yake et al. (1986) analyzed metals, PAH [including benzo(a)pyrene], and PCB in sediments from Lake Union and Chester Morse Reservoir to test the triad approach (bioassays, benthic infauna analysis, and chemical analysis). All of these studies address contaminated sediments but include reference area data.

Metro published a study on the status of and recommendations for Lake Meridian (Davis et al. 1978) and a baseline-level study of Lake Union (Tomlinson et al. 1977). Davis et al. (1978) provided only sediment lead concentrations for Lake Meridian and determined that preventing runoff material from entering the lake was necessary to ensure that the trophic level of the lake does not progress beyond its present early mesotrophic state. Tomlinson et al. (1977) assessed the contamination by metals to help determine the relative status of Lake Union.

Spyridakis and Barnes (1978) analyzed trace metals from Lake Washington, Lake Sammamish, Chester Morse Reservoir, and Findley Lake to assess contemporary and historical input to the sediments.

All of the studies mentioned above have been screened in a QA review. The data review was based on QA data provided by the laboratories and additional QA information obtained by telephone contacts. Data reviewers assessed sample collection techniques (including storage and handling times), laboratory QA analytical methods employed, and detection limits to determine the usability of the data sets. Table 19 summarizes the status of the key types of information used to assess data quality. Sample sets from localized areas of known contamination (i.e., in the immediate vicinity of the zinc refinery) have been excluded because the study goal is to determine background levels of contaminants.

7.2 CHEMICAL CONCENTRATION RANGES AND DISTRIBUTIONS

The results of the statistical analysis of the freshwater sediment data are summarized in Table 20 (including undetected values as detection limits) and Table 21 (excluding undetected values). All of the metals except chromium show a non-normal distribution in freshwater sediments (K-S test; $P>0.05$). Log transformation of the data was also unsuccessful in normalizing the data when analyzed by the K-S test. Because of their skewed nature, the data are presented in terms of detection frequency, range, mean, median, and several percentiles (10th, 25th, 75th, and 90th).

Chromium and organic compounds were normal according to the K-S test. However, the frequency distributions do not appear normal on visual examination. The K-S test may provide misleading results because of the small number of data points. The test measures the largest deviation from a normal curve as its index. When there are only a few samples, the deviations from normal are small, and the K-S test gives positive results. The statistical data for chromium and organic chemicals are therefore presented as above.

Analytes missing from the data sets described above include VOC, PCP, EDB, and 2,3,7,8-TCDD. The remaining organic data are geographically limited. Benzo(a)pyrene (BaP) concentrations from Yake et al. (1986) are qualified as estimates because of the presence of BaP in blanks. It is not known if BaP was below the detection limit in any samples.

TABLE 19. DATA REVIEW SUMMARY FOR FRESHWATER SEDIMENTS

Study		Chemical Groups Included	Study Acceptable?	# of Samples	Sample Collection	Sample Handling/ Storage	QA/QC	Analytical Methods	Limits of Detection
Johnson et al.	1988	Metals	Yes	16	A[a]	A	A	A	A
Johnson et al.	1986	DDT, PCB	Yes	13	A	A	A	A	A
Johnson and Norton	1988	Metals, PAH	Yes	10	A	A	A	A	A
Yake et al.	1986	Metals, BaP[b], PAH PCB	Yes	1	A	A	A	A	A
Ebbert et al.	1987	Metals	Yes	16	A	A	A	A	A
Davis et al.	1978	Metals (Pb only)	Yes	22	A	A	A	A	N[c]
Spyridakis & Barnes	1978	Metals	Yes	59	A	A	A	A	N
Tomlinson et al.	1977	Metals	Yes	1	A	A	A	A	A

[a] A = Acceptable

[b] Benzo(a)pyrene

[c] N = Not available

TABLE 20. FRESHWATER SEDIMENTS DATA CHARACTERISTICS[a] (USING ALL DATA)

Chemical	Frequency of Detection	Range	Mean	Median	Percentile 10	25	75	90
Metals								
As	32/32	0.80-42	6.4	3.4	1.4	2.1	7.5	10
Pb	52/59	<5.0-390	94	33	9.0	12	210	310
Cr	25/25	7.0-190	57	58	9.0	13	81	100
Cd	25/36	<0.050-52	2.6	0.50	0.10	0.22	0.80	5.4
Cu	36/36	6.0-160	34	24	12	15	36	67
Zn	37/37	27-980	220	84	40	60	130	850
Volatile Organic Compounds								
1,1,1-TCA	--	--	--	--	--	--	--	--
TCE	--	--	--	--	--	--	--	--
PCE	--	--	--	--	--	--	--	--
CH_2Cl_2	--	--	--	--	--	--	--	--
Semivolatile Organic Compounds								
PCP		--	--	--	--	--	--	--
PAH	7/7	6.0-690	330	270	6.0	26	580	690
PCB	0/13	<1.5	--	--	--	--	--	--
BaP[b]	8/8	13-190	95	110	13	33	120	190
Pesticides								
DDE	13/13	0.13-130	23	7.0	0.41	1.2	30	66
DDD	12/13	<0.10-37	7.1	2.2	0.33	0.35	67	17
DDT	12/13	<0.10-68	16	4.1	0.44	2.4	21	52
Dioxin								
2,3,7,8-TCDD	--	--	--	--	--	--	--	--

[a] All values for metals are in units of mg/kg, and all values for organics are in units of μg/kg.

[b] Benzo(a)pyrene; all data are estimated because of BaP in blanks.

TABLE 21. FRESHWATER SEDIMENTS DATA CHARACTERISTICS[a] (OMITTING DATA BELOW DETECTION LIMITS)

Chemical	N[b]	Range	Mean	Median	Percentile 10	25	75	90
Metals								
As	32	0.8-42	6.4	3.4	1.4	2.1	7.5	10
Pb	52	5.0-392	110	41	10	14	210	310
Cr	25	7.0-190	57	58	9.0	13	81	100
Cd	25	0.050-52	3.5	0.50	0.090	0.22	1.4	5.5
Cu	36	6.0-160	34	24	12	15	36	67
Zn	37	27-981	216	84	40	60	130	850
Volatile Organic Compounds								
1,1,1-TCA	--	--	--	--	--	--	--	--
TCE	--	--	--	--	--	--	--	--
PCE	--	--	--	--	--	--	--	--
CH_2Cl_2	--	--	--	--	--	--	--	--
Semivolatile Organic Compounds								
PCP	--	--	--	--	--	--	--	--
PAH	7	6-690	333	270	6.0	26	580	690
PCB	0	--	--	--	--	--	--	--
BaP[c]	8	13-190	95	110	13	33	120	190
Pesticides								
DDE	13	0.13-130	23	7.0	0.41	1.2	30	66
DDD	12	0.10-37	7.7	2.2	0.35	1.0	6.7	17
DDT	12	0.10-68	17	4.1	0.51	2.4	21	52
Dioxin								
2,3,7,8-TCDD	--	--	--	--	--	--	--	--

[a] All values for metals are in units of mg/kg, and all values for organics are in units of μg/kg.

[b] N = number of samples.

[c] Benzo(a)pyrene; all data are estimated because of BaP in blanks.

7.3 ADDITIONAL RELEVANT STUDIES

The ambient monitoring program conducted by Ecology will provide additional information on background concentrations of chemicals in sediments after changes in sampling and analytical protocols have been implemented. Freshwater sediment data collected to date have been criticized on the basis of these protocols (Hopkins, B., 1 February 1989, personnel communication) and were not included in this report.

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