Washington State Toxics Monitoring Program

Toxic Contaminants in Fish Tissue and Surface Water in Freshwater Environments, 2002

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Washington State Toxics Monitoring Program

Toxic Contaminants in Fish Tissue and Surface Water in Freshwater Environments, 2002

by
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September 2004

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Abstract

The goal of the Washington State Toxics Monitoring Program is to investigate the occurrence and concentrations of toxic contaminants in edible fish tissue and surface waters from freshwater environments in Washington. This program was started in 2001 by the Washington State Department of Ecology due to increasing concerns about contaminants in our environment.

During this 2002 exploratory monitoring effort, 12 composite samples of edible tissue were analyzed, representing six species collected from eight sites. Levels of PCBs and PCDD/Fs in fish tissue frequently exceeded criteria for the protection of human health, while levels of DDT, dieldrin, and mercury showed fewer exceedances. Other contaminants detected in fish tissue were chlordane compounds, hexachlorobenzene, pentachloroanisole, methoxychlor, and PBDEs.

Water samples collected from nine sites were analyzed for 115 chlorinated, organophosphorous, and nitrogen pesticides. Seventeen pesticides were detected at low levels and low frequencies. The most frequently detected pesticides were diuron, dichlobenil, bromacil, diazinon, and the herbicide breakdown product 2,6-dichlorobenzamide. Two results for diazinon exceeded a chronic criterion for the protection of aquatic life.

Recommendations include (1) evaluating potential human health risks from consumption of contaminated fish, and (2) placing six sites in Category 5 of Washington's 303(d) list.

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Summary

Humans and wildlife face a variety of risks due to toxic chemicals in the environment. For many areas of Washington, information is lacking about the levels of toxic contamination in freshwater fish and surface water. Renewed concern about toxic contamination of freshwater fish, water, and wildlife was addressed during 2000, and the Washington State Department of Ecology (Ecology) directed resources to develop a Washington State Toxics Monitoring Program (WSTMP). The primary goal of the project is to provide information to resource managers and the public about the status of toxic contaminants in water and edible fish from freshwater environments in Washington.

Exploratory monitoring began in 2001 with collection of more than 140 fish from 14 sites (Seiders, 2003). Edible fish tissue from samples were analyzed for mercury, chlorinated pesticides, polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), polychlorinated dibenzo-p-dioxins and polychlorinated dibenzo-p-furans (PCDD/Fs), and lipids. Water samples from four lakes were analyzed for chlorinated pesticides.

Fish Tissue Samples

The 2002 monitoring effort analyzed toxic contaminants in 12 composite samples using edible tissue from 106 individual fish representing six species collected at eight sites. Contaminants detected included mercury, PCBs, PCDD/Fs (commonly called dioxins and furans), DDT and chlordane compounds, dieldrin, hexachlorobenzene, pentachloroanisole, methoxychlor, and PBDEs. Many of these contaminants are commonly found in Washington fish.

Mercury was detected in all 11 tissue samples analyzed with the highest levels found in largemouth bass. One sample exceeded EPA's (2002c) recommended human health criterion of 300 parts per billion, wet weight (ppb ww). Seven of 11 samples exceeded one of EPA's screening values (SVs) for the protection of human health (EPA, 2000a).

Total PCBs levels in tissue samples ranged from 3.7 to 36 ppb ww. Levels in seven of 11 samples exceeded the National Toxics Rule (NTR) criterion of 5.3 ppb ww (40CFR141) while nine samples exceeded EPA SVs. PCBs were not detected in two samples.

PCDD/Fs were detected in five of eight tissue samples, and each exceeded the NTR criterion of 0.07 parts per trillion wet weight (ppt ww). Levels of PCDD/Fs, expressed as 2,3,7,8-TCDD Toxicity Equivalent, ranged from 0.0702 to 0.1917 ppt ww. Each of these five samples also exceeded an EPA SV.

Chlorinated pesticides were detected in all 11 tissue samples analyzed for these compounds. Total DDT in two of 11 tissue samples exceeded one EPA SV. None of the tissue samples exceeded the NTR criterion for 4,4'-DDE, 4,4'-DDD, or 4,4'-DDT (31.6, 45.0, and 31.6 ppb ww, respectively). The only dieldrin detection in tissue exceeded the NTR criterion of 0.65 ppb ww; this also exceeded EPA SVs. Other detected pesticides did not exceed NTR criteria or EPA SVs.

PBDEs were detected in five of 11 tissue samples with most at low levels near detection limits. There are no human health criteria for PBDEs.

Water Samples

Water samples were collected from nine sites and analyzed for 115 chlorinated, organophosphorous, and nitrogen pesticides.

Seventeen pesticides were detected at low levels and low frequencies in water samples from the nine sites. Pesticides included 11 herbicides, four insecticides, one fungicide, and one breakdown product. Pesticides that were most frequently detected included diuron, dichlobenil, bromacil, diazinon, and the herbicide breakdown product 2,6-dichlorobenzamide. Two estimated results for diazinon exceed the chronic criterion of 0.04 recommended by Menconi and Cox (1994). No other pesticides were detected at levels exceeding water quality criteria.

Introduction

Humans and wildlife face a variety of risks due to toxic chemicals in the environment. For many areas of Washington, information is lacking about the levels of toxic contamination in freshwater fish and surface water. Contaminants of particular concern include mercury, PCBs, PCDD/Fs, chlorinated pesticides, and PBDEs.

These chemicals are persistent: they do not break down easily, and they remain in the environment for decades. Many of these chemicals also bioaccumulate and biomagnify in organisms: concentrations increase at higher trophic levels because the contaminant is not broken down or excreted by metabolic processes. The accumulation of these chemicals can have a variety of health effects on humans and wildlife such as reproductive abnormalities, neurological problems, and behavioral changes.

Past monitoring efforts in Washington have detected toxic contaminants in surface water, sediment, and aquatic animal tissues. In many studies, concentrations of toxic chemicals in water, sediment, and tissue have been high enough to threaten the health of humans, wildlife, and fish. The Washington State Department of Health (Health) currently lists 13 consumption advisories for finfish and shellfish in Washington State due to contamination by mercury, PCBs, PCDD/Fs, chlorinated pesticides, and /or other metals and organic chemicals (Health, 2004). In June 2003, Health issued a statewide fish consumption advisory for smallmouth and largemouth bass due to mercury contamination (Health, 2003).

Efforts to monitor toxic chemicals in freshwater fish tissue, sediments, water, and wildlife in Washington declined over the last decade due to budget reductions. Renewed concern about impacts on fish and wildlife was addressed in 2000 by an Ecology workgroup, and resources were directed to the development of a statewide toxics monitoring program.

The goals of the Washington State Toxics Monitoring Program (WSTMP) are to:

- Conduct exploratory monitoring to identify new instances and locations of toxics contamination in freshwater environments.
- Conduct trend monitoring for persistent toxins using residues in edible fish tissue (under development).
- Provide a mechanism to disseminate information to citizens and resource managers about toxics contamination. (Website: <http://www.ecy.wa.gov/programs/eap/toxics/index.html>).
- Develop other toxics monitoring efforts to address particular issues, and establish cooperative programs with other agencies.

Exploratory monitoring was the first component of the WSTMP to be implemented. A project plan was developed in March 2001 (Seiders and Yake, 2001) which guided the initial year of the program. This report presents the results from the second year (calendar year 2002) of the exploratory monitoring component.

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Study Design

The study approach for the exploratory monitoring component of the WSTMP involved reviewing existing data on fish tissue and water contaminant levels and then selecting sites for monitoring, target analytes, and fish species. To address the human and wildlife concerns, chemicals that bioaccumulate and persist in fish tissue were selected as target analytes: mercury, PCBs, PCDD/Fs, chlorinated pesticides, and PBDEs.

Game fish were selected as the preferred species for monitoring because they are more commonly pursued and consumed by humans than are other species. Game fish, being at a higher trophic level than many non-game fish, are expected to contain higher levels of contaminants due to bioaccumulation and biomagnification.

Water quality sampling efforts aimed to characterize pesticide contamination of water at various times throughout the growing season when pesticides are commonly used in urban and agricultural landscapes. Target analytes for water included 115 chlorinated, organophosphorous, and nitrogen pesticides, total organic carbon (TOC), total suspended solids (TSS), conductivity, pH, and temperature.

Site Selection

Site selection used the process described in the project plan (Seiders and Yake, 2001) and considered a number of factors such as:

- The potential for site contamination.
- Existences and nature of historical fish tissue or water quality data.
- Value and interest of the fish resource to consumers.
- Nature of the fish resource (e.g., species present, management practices).
- Ability to obtain Scientific Collection Permits from federal and state agencies.
- Scheduling of the Basin Scoping Process according to Ecology's Watershed Approach to Water Quality which runs on a five-year cycle.

Sampling sites for the 2002 WSTMP are shown in Figure 1. Appendix A has detailed information on the locations.

Fish samples were obtained from seven sites throughout the state during the latter half of 2002. In several cases, the WSTMP used fish collected during other studies. Archived tissue from upper Long Lake fish collected in 2001 was also analyzed for PCDD/Fs; this tissue was collected in the course of a PCB and metals study (Jack and Roose, 2002). Largemouth bass collected for a statewide mercury screening study (Fischnaller et al., 2003) were analyzed for organic contaminants under this program. Similarly, rainbow trout collected from Conners Lake as part of an arsenic survey (Jack, 2003) were analyzed for organic contaminants as part of the WSTMP. For the WSTMP, at least one species of fish was obtained from each site, with five to ten fish of each species forming a composite sample as recommended by EPA (2000a).

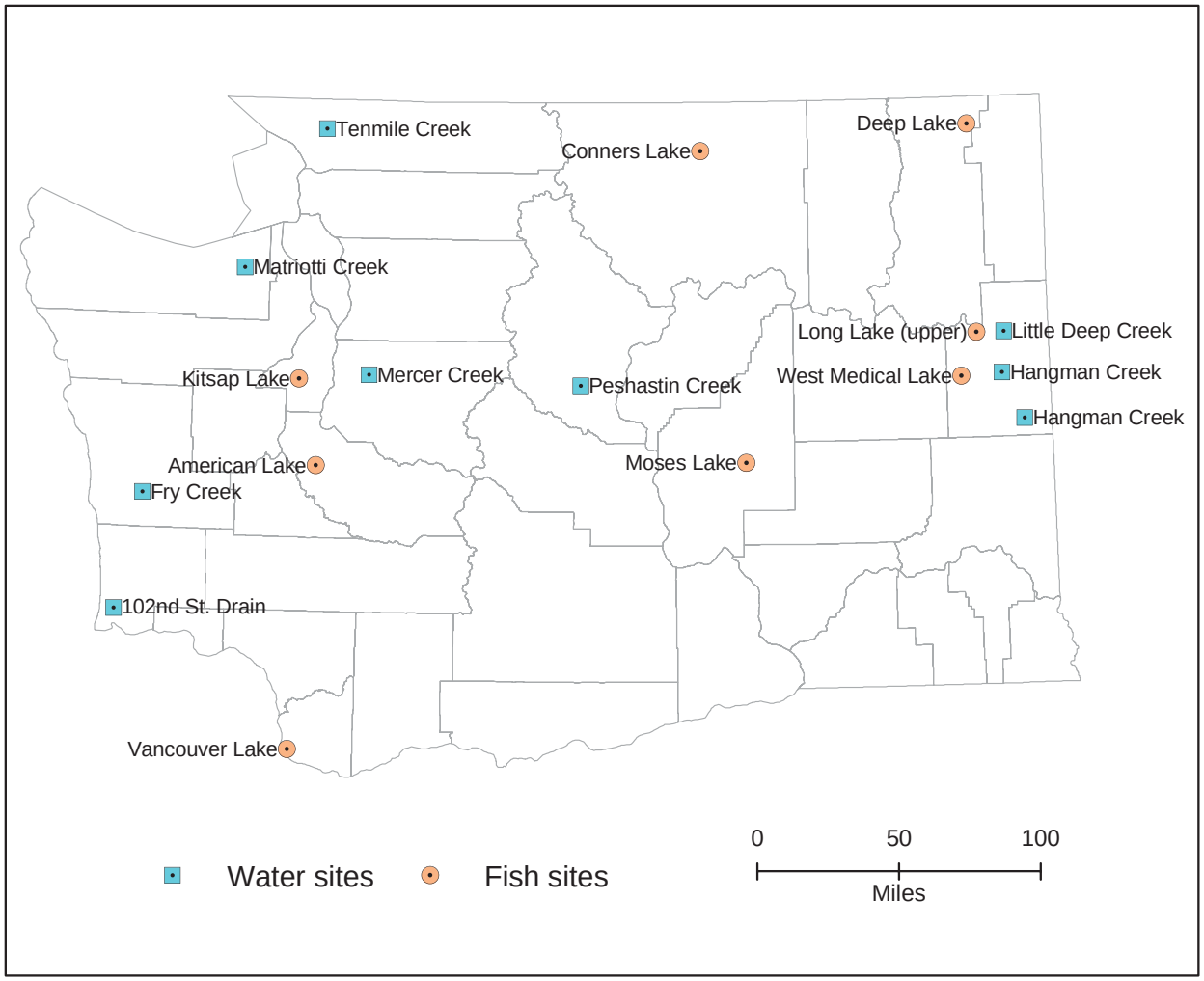

Figure 1. Sample Sites for the 2002 Washington State Toxics Monitoring Program.

Water samples were collected from nine sites during 2002. Sites included urban, rural, and agricultural settings where there was reasonable potential for pesticide contamination due to land use. Each site was sampled three times during the spring and summer months except for those on Latah Creek: the Hatch Road site was sampled only once, and the site near Waverly was sampled only twice.

Target Fish Species

Target species were selected based on recommendations from EPA (2000a) and previous experience with fish collection efforts in Washington. Edible game fish were the primary target for collection as described above. Table 1 lists the sites, species collected in 2002, and target analytes.

The following criteria were used to select target species:

- Commonly captured and likely to be consumed by humans.
- Potentially bioaccumulate high concentrations of chemicals of interest.
- Abundant, easy to identify, and easy to capture.
- Large enough to provide adequate tissue for analysis.
- Most of lifecycle spent relatively close to the sampling site.

Table 1. Sample Sites, Fish Species, and Target Analytes for the 2002 WSTMP.

Site	Species	Number of Fish in Composite Sample	Total Length (mm)	Target Analytes			MEL [1] Sample ID (03-)
				OC Pest, PCB, PBDE	Hg	PCDD PCDF	
American Lake	Kokanee	9	291-379	x	x	x	187203
Conners Lake	Rainbow trout	10	312-410	x	x	x	187210
Deep Lake	Cutthroat trout	10	250-281	x	x		187202
Kitsap Lake	Largemouth bass	10	310-495	x	x		187200
	Cutthroat trout	7	255-298	x	x	x	187201
	Rainbow trout	5	225-435	x	x	x	187204
Long Lake (upper)	Mountain whitefish	10	265-306			x	187212
Moses Lake	Largemouth bass	10	322-570	x	x		187206
	Rainbow trout	6	470-520	x	x	x	187208
	Walleye	9	415-515	x	x	x	187211
Vancouver Lake	Largemouth bass	10	260-470	x	x		187207
West Medical Lake	Rainbow trout	10	350-445	x	x	x	187205

1 - Manchester Environmental Laboratory

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Methods

Field Procedures

Fish Tissue Samples

The collection, handling, and processing of fish tissue samples for analysis were guided by methods described by EPA (2000a). Fish were captured by angling, gillnetting, or electrofishing with a 16' Smith-Root electrofishing boat. Captured fish were identified to species, and target species were retained while non-target species were released. Retained fish were inspected to ensure that they were acceptable for further processing (e.g., proper size, no obvious damage to tissues, skin intact). Field preparation of individual fish involved assigning an identification code, measuring length and weight, wrapping in foil and plastic zip-lock bags, and placing on ice for transport to a freezer for storage at -20 C.

Fish were processed at a later date to form samples that would be sent to the laboratory for analysis. One or both fillets were removed for use in composite samples. For analysis of organic compounds, at least five fish of the same species were used to create a composite sample for each site sampled. Field sampling and fish processing procedures are further described in Appendix B.

Water Samples

Water samples were collected from three points along a transect across each stream using a US DH81 sampler with a pre-cleaned, one-quart collection jar. At each point, the sampler was lowered from the water surface to the stream bottom and back to the surface to obtain a depth-integrated sample. Samples from each transect were then combined in a pre-cleaned, one-gallon glass jar for pesticides. Sample containers for general chemistry were likewise filled. All containers were placed on ice and delivered to the laboratory within 24 to 72 hours.

In-situ measurements included water temperature, conductivity, pH, and streamflow. These measurements were recorded in field notebooks along with location, time, and other comments. Field sampling procedures are further described in Appendix B.

Laboratory Procedures

Fish Tissue Processing

Frozen fish were processed at Ecology's Lacey headquarters and samples then sent to Ecology's Manchester Environmental Laboratory (MEL) for analyses. The edible portion of target species was used for composite samples. For all fish except largemouth bass, skin-on fillets from five to ten fish of the same species from the same site were used to create a composite sample. The largemouth bass samples were created from archived skin-off fillet tissue samples collected during the statewide mercury study (Fischnaller et al., 2003).

Fillets were passed through a Kitchen-Aid® food grinder three times for grinding and homogenizing the tissue sample. Equal amounts of the ground and homogenized tissue from each fillet were combined to form a single composite sample. An aliquot of the homogenized tissue was placed in a pre-cleaned jar (I-Chem 200) for transport to the laboratory. The abdominal cavity of the fish was then opened to determine gender. Fish scales and otoliths were removed for age determination by Washington Department of Fish and Wildlife (WDFW) biologists in Olympia, WA.

All utensils used for tissue processing were cleaned in order to prevent contamination of the sample. The cleaning procedure involved soap and water washes followed by acid and solvent rinses. Appendix B more fully describes the tissue processing procedures used.

Analytical Methods

Table 2 describes the analytical methods used for fish tissue and water samples. These methods were selected to achieve a balance of analytical sensitivity, comparability, and cost-effectiveness. The quantitation limits of these methods were adequate for most analytes, yet some quantitation limits were higher than water quality criteria or screening levels – depending upon performance of the analytical system at the time of analysis. For tissue samples, these analytes include toxaphene and sometimes PCBs and PCDD/Fs.

For water samples, these analytes include DDT and chlordane compounds, aldrin, chlorpyrifos, dieldrin, endrin, endosulfan, heptachlor, lindane, and parathion. Typical reporting limits for target analytes can be seen in Appendix C, Tables C-3 and C-4 for tissue and Table C-7 for water. (These are the values qualified with a U or UJ indicating that the analyte was not detected at the stated reporting limit.)

All samples were analyzed at MEL except PCDD/Fs. Pace Analytical, Incorporated of Minneapolis, MN analyzed tissue samples for PCDD/Fs.

Table 2. Analytical Methods for Fish Tissue and Water Samples, WSTMP 2002.

Parameter	Description	Method	Practical Quantitation Limit
Tissue Samples			
Mercury	CVAA	EPA 245.5; MEL SOP [1]	0.005 mg/kg, wet wt
Chlorinated pesticides	GC/ECD	EPA 8081; MEL SOP [2]	0.25 -15 ug/kg, wet wt
PCBs and PBDEs	GC/ECD	EPA 8082; MEL SOP [2]	0.25 ug/kg, wet wt
PCDD/PCDFs	HiRes GC/MS	EPA 1613B	0.1 - 1.0 ng/kg, wet wt
Lipids - percent	gravimetric	EPA 608.5 [3]	0.1%
Water Samples			
Pesticides (OC, OP, N)	GC/AED with GC/MS confirmation	EPA 8085; MEL SOP [4]	0.01- 1.0 ug/L
Total organic carbon	Combustion NDIR	EPA 415.1	1 mg/L
Total suspended solids	gravimetric	EPA 160.2	1 mg/L

Manchester Environmental Laboratory (MEL) modifications to analytical methods are documented in their Standard Operating Procedures:

1. EPA 245.5: "Standard Operating Procedure for the Determination of Mercury by Cold Vapor Atomic Absorbance in Sediments US EPA SW846 7471B Modified, and 245.5, Modified (Sediment)" (Also used for tissue).
2. EPA 8081 and EPA 8082 - SOP # 730002: Analysis of Water/Soil/Sediment/Fish Tissue Samples for Organochlorine Pesticides, Polybrominated Diphenyl Ethers and Polychlorinated Biphenyls by GC/ECD.
3. Extraction solvents were methylene chloride and hexane. 1:1 by volume.
4. EPA 8085 - SOP # 730001: Pesticides Screening and Compound Independent Elemental Quantitation by Gas Chromatography with Atomic Emission Detection (AED), Method 8085.

Data Quality Assessment

A detailed review of data quality is contained in Appendix C. Quality control procedures included analysis of method blanks, matrix spikes, matrix spike duplicates, surrogate recoveries, laboratory duplicates, and field duplicates. Quality control and quality assurance data from laboratories were reviewed and indicated that analytical systems performance was adequate, with most data meeting objectives for quality control. Some data were qualified due to difficulties encountered in analyses of the samples, and all results were useable as qualified.

For pesticide/PCB/PBDE analyses of fish tissue, results for some chlorinated pesticides and PCB Aroclor 1260 were affected by problems with poor recovery performance for calibration standards, control standards, surrogates, and matrix spikes (Mandjikov, 2004). These samples were re-extracted and re-analyzed to improve data quality. About 8% of the more than 500 pesticide results were qualified as estimated values (flagged J or NJ). The detection limits for analytes not detected were estimated for about 21% of the results (flagged UJ).

For PCDD/Fs analyses of fish tissue, reporting limits did not meet the desired limits defined in the project plan (0.1 – 1.0 parts per trillion) due to an inadequate amount of tissue sample used for extraction (10 g vs 25 g). Upon request, Pace Analytical reviewed the raw data to determine if lower reporting limits could be justified and results reported to the lowest detection limit. Where these results were reported below the quantitation limit, results were qualified as estimates (Feddersen, 2003).

Results from quality control practices for water samples showed that the analytical system performed adequately and that data are useable as qualified.

Results and Discussion

Fish Tissue Samples

Contaminants Detected

Most sites yielded a single species for analysis; Moses Lake and Kitsap Lake produced multiple species. Rainbow trout (*Oncorhynchus mykiss*) were collected at four sites with the largest fish being from Moses Lake (Table 1). Largemouth bass (*Micropterus salmoides*) were collected from three sites with the largest fish again from Moses Lake. Cutthroat trout (*Oncorhynchus clarki*) from Deep and Kitsap lakes were among the smallest fish (250-298 mm total length) collected. Eight of the ten largemouth bass from Vancouver Lake were also small (260-290 mm total length) while the other two bass measured 405 mm and 470 mm total length. Fish from Moses Lake were among the largest of those collected in 2002. Appendix D, Table D-1 contains field data for all fish collected.

Table 3 summarizes the range of contaminant levels detected in fish tissue. The most frequently detected analytes were mercury and 4,4'-DDE (100% of samples), PCBs (82%), dioxins and furans (63%), 4,4'-DDD (55%), and trans-nonachlor (36%). PBDE-47 was detected in 45% of the tissue samples.

Table 4 summarizes contaminants that exceeded either Washington's Water Quality Standards or EPA's Screening Values (EPA, 2000) for the protection of human health. These criteria are shown in Table 5 and further described below. Chemicals that exceeded one or more human health criteria included total PCBs, PCDD/Fs, total DDT, and dieldrin.

Most samples exceeded criteria for multiple contaminants. For example, of the 15 chemicals detected in American Lake kokanee, four exceeded criteria or screening values for the protection of human health. Levels of three chemicals exceeded criteria or screening values in these samples: Kitsap Lake cutthroat trout, Moses Lake largemouth bass and rainbow trout, and West Medical Lake rainbow trout which had the highest levels of PCBs found in 2002.

Table D-2 shows results for PCBs, PCDD/Fs, chlorinated pesticides, PBDEs, mercury, and lipids in fish tissue samples. American Lake kokanee were the most contaminated fish with 15 compounds. Moses Lake rainbow trout had nine contaminants detected, largemouth bass had six, and walleye (*Stizostedion vitreum*) had four contaminants detected. Kitsap Lake rainbow and cutthroat trout each had six contaminants. Kitsap Lake largemouth bass had four contaminants and the highest mercury level of fish sampled in 2002. Vancouver Lake largemouth bass had five contaminants. Deep Lake cutthroat trout and Conners Lake rainbow trout were the least contaminated fish sampled in 2002. Long Lake mountain whitefish (*Prosopium williamsoni*) were analyzed only for PCDD/Fs as part of this study, and these were detected at levels exceeding criteria.

Table 3. Summary of Contaminant Levels Detected in Fish Tissue, WSTMP 2002.

Analyte	Number of Detections	Frequency of Detection	Minimum Value		Maximum Value		Median Value
Mercury (ppb ww)	11	100%	15		313		86
PCBs (ppb ww)							
PCB-1248	1	9%	3.2	NJ	3.2	NJ	-
PCB-1254	9	82%	3.7	J	25		6.8
PCB-1260	6	55%	2.8	NJ	11	J	4.5
Total PCBs	9	82%	3.7		36		12
PCDD/Fs (ppt ww) [1]	5	63%	0.0702	J	0.1917		0.086
Chlorinated Pesticides (ppb ww)							
2,4'-DDE	1	9%	1.8		1.8		-
4,4'-DDD	6	55%	0.44	J	5.9		1.5
4,4'-DDE	11	100%	1.1		23		2.7
4,4'-DDT	1	9%	0.75	J	0.75	J	-
Total DDTs	11	100%	1.1		30.7		3.1
Cis-Chlordane (Alpha-Chlordane)	1	9%	0.81	J	0.81	J	-
Trans-Nonachlor	4	36%	0.46	J	1.5		0.57
Total Chlordanes	4	36%	0.46		2.31		0.57
DDMU	1	9%	1.6	J	1.6	J	-
Dieldrin	1	9%	1.2		1.2		-
Hexachlorobenzene	2	18%	0.41		2.2		1.3
Pentachloroanisole	2	18%	0.41	NJ	1.1	J	0.76
Methoxychlor	1	9%	1.2	NJ	1.2	NJ	-
PBDEs (ppb ww)							
PBDE-47 (2,2',4,4'-tetraBDE)	5	45%	1.2		4.3		1.8
PBDE-99 (2,2',4,4',5-pentaBDE)	2	18%	0.84	J	1.1	J	0.97
PBDE-100 (2,2',4,4',6-pentaBDE)	1	9%	1.7	J	1.7	J	-
Total PBDEs	5	45%	1.2		6.84		1.8
Lipids (percent)	12	100%	0.44		8.1		1.7

ppb ww - parts per billion (ug/Kg), wet weight.
ppt ww - parts per trillion (ng/Kg), wet weight.

J - The analyte was positively identified. The associated numerical value is an estimate.
NJ - There is evidence that the analyte is present. The associated numerical result is an estimate.
1 - Sum of congeners that were detected, expressed as 2,3,7,8 TCDD Toxicity Equivalents (TEQ).

Table 4. Fish Tissue Contaminants Exceeding NTR Criteria or EPA Screening Values for the Protection of Human Health, WSTMP 2002.

Site	Species	Mercury (ppb ww)	Total PCBs (ppb ww)	PCDD & PCDFs (ppt ww)	Total DDT (ppb ww)	Dieldrin (ppb ww)	Lipids (percent)
Vancouver Lake	Largemouth bass	*160*	6.0	-	-	-	0.44
Kitsap Lake	Largemouth bass	*313*	4.7	-	-	-	0.99
Kitsap Lake	Cutthroat trout	91	11.5	0.0702 [2]	-	-	1.8
Kitsap Lake	Rainbow trout	96	9.6	-	-	-	1.8
American Lake	Kokanee	90	20.5	0.1917	-	1.2	8.1
Moses Lake	Largemouth bass	*86*	17.9	-	16.4	-	1.5
Moses Lake	Walleye	-	3.7	-	-	-	1.2
Moses Lake	Rainbow trout	-	11.8	0.1200	30.7	-	4.4
West Medical Lake	Rainbow trout	60	36.0	0.0840	-	-	2.4
Long Lake (upper)	Mountain whitefish	-	-	0.0860	-	-	1.7
National Toxics Rule criteria		825	5.3	0.0700	31.6 / 45 [3]	0.65	-
EPA screening value for subsistence fishers		49	2.45	0.0315	14.4	0.307	-
EPA screening value for recreational fishers		400	20	0.2560	117	2.5	-

ppb ww - parts per billion wet weight
ppt ww - parts per trillion wet weight

1 - Italicized results from Fischnaller et al., 2003; value is mean of 10 individual fish.
2 - Not detected in lab duplicate sample.
3 - 31.6 ppb is for 4',4'-DDE and 4',4'-DDT; 45 ppb is for 4',4'-DDD

Table 5. NTR Criteria and EPA Screening Values for the Protection of Human Health for Contaminants Detected in Fish Tissue, WSTMP 2002.

Analyte (ppb ww)[1]	National Toxics Rule	EPA Screening Values			
		Subsistence Fishers		Recreational Fishers	
		Non-carcinogens	Carcinogens	Non-carcinogens	Carcinogens
Mercury	825/300 [2]	49	-	400	-
Total PCBs	5.3	9.83	2.45	80	20
PCDD/Fs TEQ [3]	0.07	-	0.0315	-	0.256
4,4'-DDD	45	-	-	-	-
4,4'-DDE	31.6	-	-	-	-
4,4'-DDT	31.6	-	-	-	-
Total DDT	-	245	14.4	2000	117
Total Chlordane	8.3	245	14.0	2000	114
Dieldrin	0.65	24	0.307	200	2.5
Hexachlorobenzene	6.7	393	3.07	3200	25.0

1 - Values in parts per billion wet weight (ug/kg ww) unless otherwise noted.
2 - EPA (2001) has proposed 300 ppb ww as the criterion for methylmercury.
3 - Values in parts per trillion wet weight (ng/kg ww).

Criteria for Protection of Human Health

National Toxics Rule

Washington's water quality standards for toxic substances (WAC 173-201A-040[5]) define human health-based water quality criteria by referencing 40 CFR 131.36, also known as the National Toxics Rule (NTR). Washington's water quality standards further state that risk-based criteria for carcinogenic substances be based on a risk level of 10^{-6}. A risk level is an estimate of the number of cancer cases that would be caused by exposure to a specific contaminant. At a risk level of 10^{-6}, one person in a million would be expected to contract cancer due to long-term exposure to a specific contaminant. These risks are upper bound estimates, while true risks may be as low as zero. Exposure assumptions include an acceptable risk level and the consumer's body weight, length of exposure, and consumption rate. The NTR criteria are based on a consumption rate of 6.5 grams/day. Table 5 shows the NTR criteria for contaminants detected in the 2002 WSTMP fish samples.

EPA Screening Values

Screening values (SVs) for carcinogenic and non-carcinogenic substances were developed by EPA in order to aid the prioritization of areas that may present risks to human populations from fish consumption. The EPA SVs are considered guidance only; they are not regulatory thresholds (EPA 2000a).

Assumptions about exposure to contaminants were also used in developing the EPA SVs. The approach is similar to that used for developing the NTR, yet two assumptions differ for SVs: the cancer risk level (10^{-5}) and the consumption rate (17.5 grams/day for recreational fishers and 142.4 grams per day for subsistence fishers). Screening values for non-carcinogenic effects are calculated using toxicological data from a variety of tests.

The development of fish consumption advisories requires an intensive survey of substantial effort and resources to better characterize health risks from eating contaminated fish. Such surveys involve determining local fish consumption patterns, contaminant levels, toxicological aspects of the contaminant, exposure assessment, and risk characterization. Washington's Department of Health and local health departments are the agencies responsible for developing fish consumption advisories in Washington. Table 5 also shows EPA SVs for contaminants detected in the 2002 WSTMP fish tissue samples.

Criteria for Mercury

EPA recently updated its 1980 water quality criterion for methylmercury (EPA, 2001). Methylmercury is a toxic form of mercury that comprises nearly all the mercury in fish tissue (Bloom, 1995). The new (2001) recommended water quality criterion is 300 ppb. This is the maximum advisable concentration of methylmercury in fish and shellfish to protect consumers among the general population. EPA expects the criterion to be used as guidance by states, authorized Tribes, and EPA in establishing or updating water quality standards for waters of the United States. While the criterion proposed by EPA in 2001 for mercury in freshwater fish is 300 ppb ww, the NTR criterion of 825 ppb ww remains to be the value used in Washington's

Water Quality Standards for regulatory purposes. The mercury criteria discussed in this report are:

- National Toxics Rule: 825 ppb ww (based on 6.5 grams/day consumption rate).
- EPA's recommended criterion of 300 ppb ww (based on 17.5 grams/day consumption rate).
- EPA Screening Values which are 400 ppb ww for recreational fishers and 49 ppb ww for subsistence fishers (based on freshwater fish consumption rates of 17.5 and 142.4 grams/day, respectively).

Summing Results from Individual Compounds

Criteria for some analytes in this study are expressed as "total" values in order to compare them to criteria. Total PCBs is the sum of the individual Aroclors. Total DDT is the sum of the 4,4' and 2,4' isomers of DDT, DDD, and DDE. Total chlordane is the sum of five compounds; cis- and trans- chlordane, cis- and trans- nonachlor, and oxychlordane. Values qualified as estimates were included in the summing process while non-detect values were assigned a value of zero.

Criteria for Protection of Wildlife

There are no federal or state fish tissue criteria for the protection of wildlife for the state of Washington. This report uses criteria from two sources: the National Academies of Science and Engineering (NAS/NAE, 1972), and the state of New York's Department of Environmental Conservation (Newell et al., 1987).

Mercury

Background

Mercury is widespread in the environment, being released to the atmosphere from varied sources and transported globally. Mercury readily volatilizes such that 95% of atmospheric mercury is in the elemental form. Natural sources of mercury include weathering of mercury-bearing rocks and soil, volcanic activity, forest fires, and degassing from water surfaces. Anthropogenic sources include combustion of fossil fuels, metal production, and industrial processes. Lake sediment records show that atmospheric mercury has tripled over the last 150 years, suggesting that two-thirds of atmospheric mercury is of anthropogenic origin (Morel et al., 1998). Mercury returns to earth mainly via precipitation, settling in waters and land surfaces and cycling through these environments.

Mercury cycling in freshwater systems is complex. In water, mercury may bind to chloride, sulfide, and organic acids. Methylmercury is the organic form that is bioaccumulated, accounting for 95-100% of the mercury found in fish (Bloom, 1995). Methylation of mercury is believed to occur mainly in anoxic environments with sulfate-reducing bacteria playing an important role, particularly at the sediment-water interface in lakes (Morel et al., 1998; Driscoll et al., 1994). Riparian wetland processes may also be important contributors of methylmercury to some lakes (Watras et al., 1995).

Microbial uptake of mercury is a key step in its methylation and bioaccumulation. The accumulation of mercury in larger organisms is due mainly from consumption of mercury-containing prey. Methylmercury in fish is found mainly in muscle tissue rather than being associated with lipids as many other contaminants are. Bioaccumulation increases with the number of trophic levels in the food web, generally resulting in higher levels of methylmercury in top predators (Morel et al., 1998).

In humans, mercury primarily affects the nervous system, particularly in developing fetuses and children (EPA, 2000a). Concern with these health risks resulted in the 2002 State Legislature directing Ecology and Health to develop a plan targeting mercury as the first priority pollutant in the state's Proposed Strategy to Continually Reduce Persistent, Bioaccumulative Toxins (PBTs) in Washington State (Gallagher, 2000). The Washington State Mercury Chemical Action Plan (Peele, 2003) identifies sources of mercury in Washington, current institutional structures related to mercury, and strategies for reducing mercury in the environment.

Human Health Criteria Exceedances

Mercury was detected in all WSTMP fish samples with one sample exceeding EPA's recommended criterion of 300 ppb ww (Table 3 and Appendix D, Table D-2). This exceedance of 313 ppb ww was in largemouth bass from Kitsap Lake (Table 4). The next highest value of 160 ppb ww was found in largemouth bass from Vancouver Lake. EPA's SV for subsistence fishers, 49 ppb ww, was exceeded by seven of 11, or 64%, of the samples. No samples exceeded the NTR criterion of 825 ppb ww or EPA's SV for recreational fishers of 400 ppb ww.

Wildlife Criteria Exceedances

None of the 2002 WSTMP samples exceeded the National Academies of Sciences and Engineering (NAS/NAE, 1972) recommended criterion for the protection of wildlife (Table 6). This criterion suggested that fish-eating birds should be protected if mercury levels in fish do not exceed 500 ppb ww. The NAS/NAE recognized that the 500 ppb ww criterion provided little or no safety margin for fish-eating wildlife and recommended that the criterion be updated. There has yet to be an update to this criterion.

Table 6. Fish Tissue Criteria for the Protection of Wildlife.

Analyte (ppb ww) [1]	NAS/NAE [2]	NY DEC [3]	NY DEC [4]
Mercury	500	-	-
Total PCBs	500	110	110
PCDD/Fs [5]	-	2.3	3.0
Total DDT	1000	270	200
Total Chlordane	100	370	500
Dieldrin	-	22	120
Hexachlorobenzene	-	200	330

1 - Values in parts per billion wet weight (ug/kg ww) unless otherwise noted.

2 - National Academies of Sciences and Engineering, 1972.

3 - Newell et al., 1987. N.Y. Department of Environmental Conservation: One-in-100 cancer risk criteria for piscivorous wildlife.

4 - Newell et al., 1987. N.Y. Department of Environmental Conservation: Non-carcinogenic final fish flesh criteria for piscivorous wildlife.

5 - PCDD/Fs as 2,3,7,8-TCDD TEQ; values in parts per trillion wet weight (ng/kg ww).

Statewide Comparison

For a statewide perspective, mercury levels in freshwater fish from various studies are ranked in Figure 2 as cumulative percentiles with the results from 2002 indicated for each sample. Largemouth bass from Kitsap and Vancouver Lakes had the highest mercury levels in 2002, each exceeded the 50th percentile of all mercury values. Fish from the other sites ranked below the 35th percentile.

The 648 values used in Figure 2 are from monitoring conducted by Ecology, EPA, and USGS (EPA, 1992; EPA, 2002a; EPA, 2002b; Fischnaller et al., 2003; Hopkins et al., 1985; Hopkins, 1991; Johnson and Norton, 1990; Serdar et al., 1994a, 1994b; Serdar and Davis, 1999; Serdar et al., 2001; and Munn et al., 1995). These studies determined mercury levels in edible tissue from multiple species using individual fish as well as composite samples of a single species.

Fischnaller et al. (2003) compared mercury levels among bass from 15 waterbodies in Washington and found largemouth bass from Moses Lake to be among those with the lowest levels of mercury. Johnson and Norton (1990) reported low mercury levels of 20 ug/kg ww in black bullhead (*Ictalurus melas*) fillets from Moses Lake in their 1989 survey.

Two Ecology studies examined mercury levels in American Lake fish. Rock bass (*Ambloplites rupestris*) fillets were analyzed for mercury and other contaminants in 1989 (Johnson and Norton, 1990). The five fish (total length 140-200 mm) composite sample had a mercury concentration of 190 ug/kg ww. Fillets from four smallmouth bass (*Micropterus dolomieui*) tested in 2002 showed mercury levels of 253-673 ug/kg ww (Fischnaller et al., 2003). The higher levels of mercury in the 2002 smallmouth bass are likely due to their larger size (total length 415-445 mm).

For the 2002 WSTMP sample results, variations in fish species, size ranges, and local environments preclude establishing any spatial patterns for mercury in fish tissue, although largemouth bass tended to have higher mercury levels than other species.

PCBs

Background

PCBs are a group of 209 synthetic chemicals whose production in the United States was banned in 1979 due to their toxicity and persistence in the environment. PCBs were manufactured in complex mixtures to attain desirable properties for varied applications, such as fire retarding properties for lubricating and electrical transformer oils. These mixtures were manufactured under many names, the most common being the “Aroclor” series.

The major source of PCBs in the environment is from historical manufacturing, storage, use, and disposal practices. Throughout the world, PCBs are found in air, soil, waters, and biota. PCBs have low solubility in water yet have a high affinity for sediments and animal fats; they readily bioaccumulate in the aquatic food chain (EPA, 1999a).

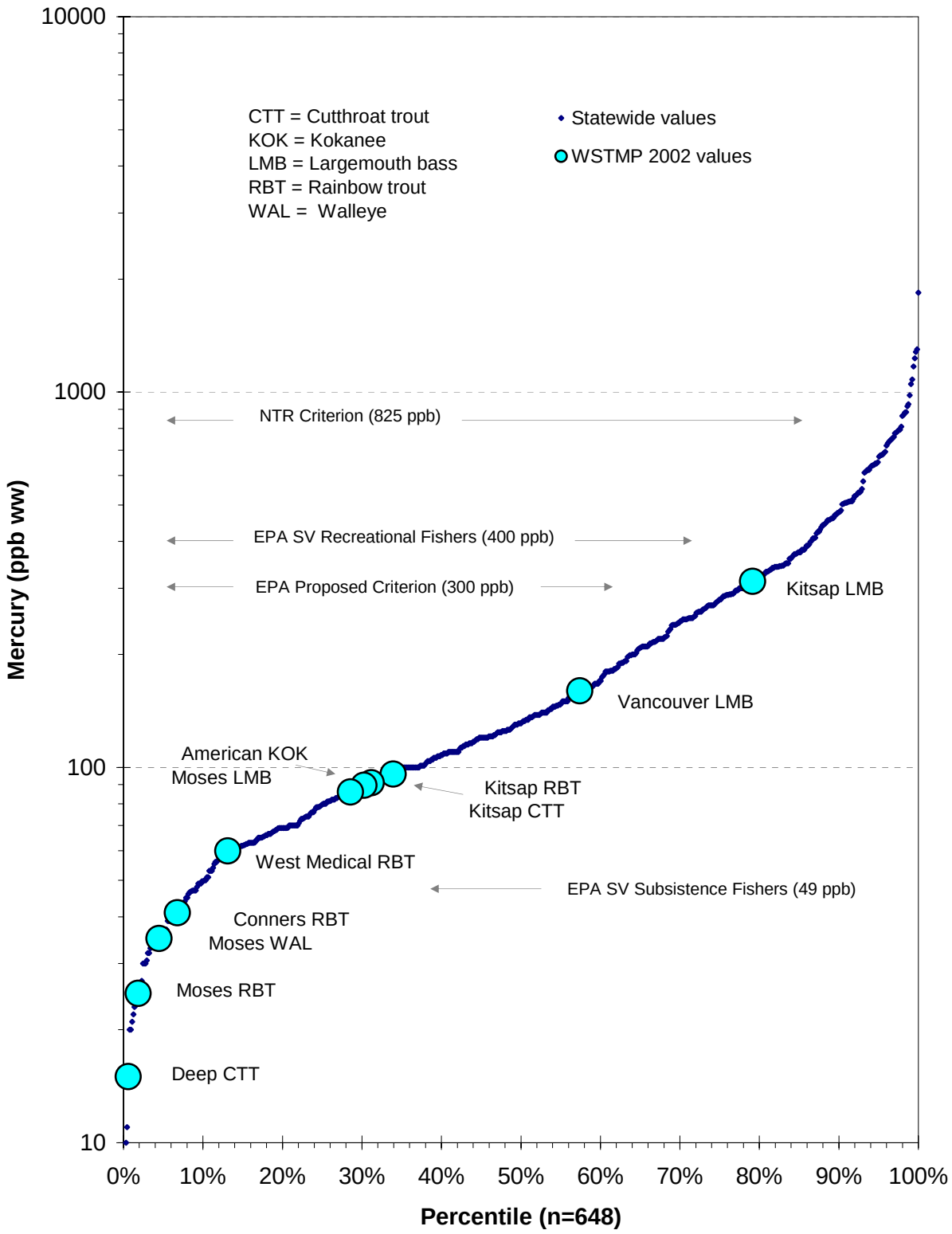

Figure 2. Cumulative Frequency Distribution of Mercury in Edible Fish Tissue.

A broad range of adverse health effects have been associated with exposure to PCBs. These include toxic effects on the nervous, endocrine, digestive, immune, and reproductive systems. PCBs are classified as a probable human carcinogen by the EPA. Thirty-seven states have issued 679 fish consumption advisories due to PCB levels. PCBs are responsible for about 27% of fish consumption advisories in the United States (EPA, 1999a).

Human Health Criteria Exceedances

Levels of total PCBs from seven of 11 tissue samples exceeded the NTR criterion of 5.3 ppb ww, and many samples exceeded one or more of EPA's SVs (Table 4 and Appendix D, Table D-2). Nine of 11 samples exceeded EPA's carcinogenic effects SV for subsistence fishers of 2.45 ppb ww. Five of 11 samples exceeded the non-carcinogenic SV for subsistence fishers of 9.83 ppb ww. Two of 11 samples exceeded EPA's carcinogenic effects SV for recreational fishers of 20 ppb ww. The recreational fisher SV of 80 ppb ww for carcinogenic effects was not exceeded.

Rainbow trout from West Medical Lake had the highest level of total PCBs (36 ppb ww) followed by kokanee from American Lake (20.5 ppb ww) and largemouth bass from Moses Lake (17.9 ppb ww). These samples exceeded the NTR criterion by factors of about 7, 4, and 3, respectively.

Wildlife Criteria Exceedances

The 2002 fish tissue samples did not exceed criteria for the protection of wildlife. The levels of total PCBs found in most samples were roughly three to ten times less than several criteria developed for the protection of wildlife (Table 6). Total PCB levels from West Medical Lake rainbow trout, American Lake kokanee, and Moses Lake largemouth bass were about one-third to one-fifth of New York's Department of Environmental Conservation (DEC) criterion of 110 ppb ww (Newell et al., 1987).

Statewide Comparison

PCBs are commonly found in freshwater fish due to their persistence and widespread historical use. For a statewide perspective, total PCBs in edible fish tissue were compiled from historical studies in Washington and plotted in Figure 3. Most results from the 2002 sampling effort fell below the 10^{th} percentile, while three samples fell between the 15^{th} and 35^{th} percentiles.

The 350 results depicted in Figure 3 represent 25 different species and include fillet and muscle tissue from individual fish as well as composite samples of multiple fish. Most edible tissue sampled for PCBs in the state exceed the NTR criterion of 5.3 ppb ww for the protection of human health and both of EPA's Screening Values for subsistence fishers (2.54 and 9.83 ppb ww). The historical data were from the following studies: Davis and Johnson, 1994; Davis et al., 1995; Davis and Serdar, 1996; Davis et al., 1998; Ecology, 1995; EPA, 1992; EPA, 2002a; EPA, 2002b; Hopkins et al., 1985; Hopkins, 1991; Jack and Roose, 2002; Johnson and Norton, 1990; Johnson, 1997a; Johnson, 2000; Serdar et al., 1994a, 1994b; Serdar, 1998; Serdar and Davis, 1999; Serdar, 1999; and Serdar, 2003.

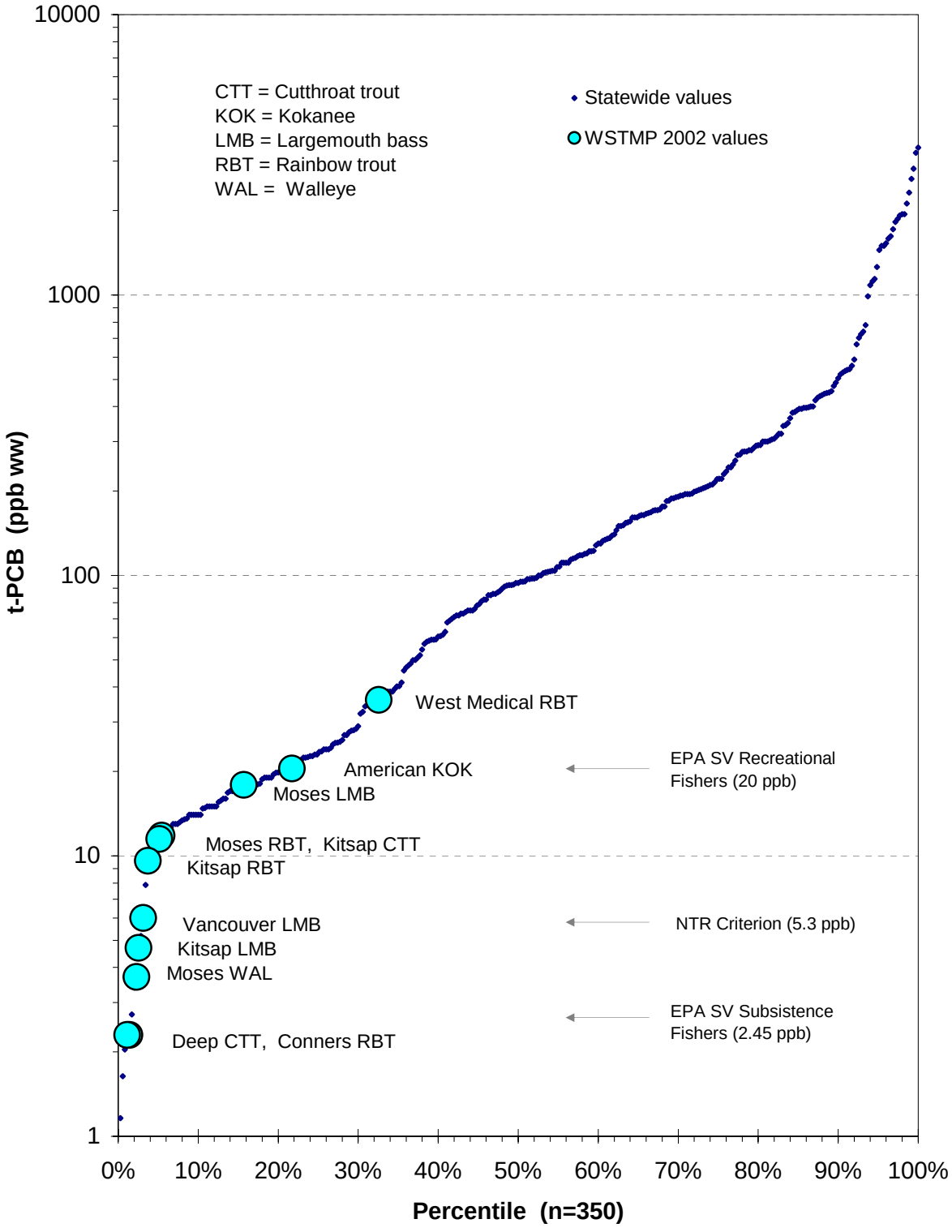

Figure 3. Cumulative Frequency Distribution of Total PCBs in Edible Fish Tissue.

Historical data for chlorinated pesticides and PCBs in fish were collected by Johnson and Norton (1990) for American Lake and Moses Lake, and by Davis et al. (1995) for Vancouver Lake. No PCBs were detected in either the rock bass sample from American Lake or the black bullhead from Moses Lake, although detection limits were two to four times greater than those for the kokanee sample analyzed for this 2002 study.

Vancouver Lake largemouth bass and common carp (*Cyprinus carpio*) collected in 1993 had PCB levels exceeding the NTR criterion as well as EPA SVs. The total PCB concentration in the 1993 largemouth bass sample was 110 ug/kg ww while that in the carp sample was 280 ug/kg ww. Each sample consisted of five fish: the largemouth bass sample used fillets while the carp sample consisted of whole fish. Differences between PCB levels in largemouth bass collected from Vancouver Lake in 1993 and 2002 could be due to several factors such as size, lipids content, analytical methods, capture location, and changes in PCB availability.

PCDD/Fs

Background

Dioxins and furans, commonly used terms for PCDD/Fs, are unintentional byproducts of combustion processes, chlorine bleaching in paper production, and contaminants in some chlorinated pesticides. Like PCBs, they are highly persistent and widely distributed in the environment. Adverse health effects have been associated with the digestive, endocrine, immune, nervous, and reproductive systems. The dioxin compound, or congener, 2,3,7,8-tetrachlorodibenzo-p-dioxin, is the most potent animal carcinogen EPA has evaluated. EPA classifies this congener as a probable human carcinogen (EPA, 1999b).

The 17 PCDD/F congeners have different levels of toxicity compared to 2,3,7,8-TCDD, the most toxic form. To assess the cumulative risks to human and environmental health, the congener concentrations are expressed as "Toxic Equivalents" (TEQ). The TEQ is calculated by multiplying each congener result by its congener-specific Toxicity Equivalent Factor (TEF) and then summing to obtain the overall TEQ.

Various TEFs have been developed over time as a result of research into the toxicity of individual congeners. The 1998 World Health Organization TEFs are used in this report because they are based on more recent research, are internationally accepted, and preferred by EPA (2002b). These TEFs are described by Van den Berg et al. (1998).

In calculating the TEQs, non-detects were assigned a value of zero, and results qualified as estimates were used at the reported value. Results for individual congeners, TEFs, and TEQs are included in Appendix D, Table D-3. Ecology's current policy for evaluating data for the federal Clean Water Act Section 303d Assessment states that summations should be based on "detected values". TEQ values based on using one-half the detection limit value for non-detects are also shown in Table D-3 since this approach has been used in the past.

Human Health Criteria Exceedances

Five of eight tissue samples exceeded the NTR criterion of 0.07 parts per trillion wet weight (ppt ww) for PCDD/Fs by a factor of 1 to 2.7 (Table 4 and Appendix D, Table D-2). The EPA SV for subsistence fishers (0.0313 ppt w) was also exceeded by these five samples by factors of about 2 to 6. PCDD/Fs were not detected in the remaining three samples. American Lake kokanee had the highest value (0.1917 ppt w) with Kitsap cutthroat trout showing the lowest at 0.0702 ppt ww.

Wildlife Criteria Exceedances

Levels of PCDD/Fs in fish tissue were below the two criteria developed by the New York DEC for the protection of wildlife (Newell et al., 1987). These criteria are 2.3 and 3.0 ppt ww for carcinogenic (a one in one hundred cancer risk) and non-carcinogenic effects, respectively (Table 6).

Statewide Comparison

Tissue data on PCDD/Fs were compiled from historical studies in Washington and plotted in Figure 4 (Johnson and Yake, 1989; Johnson et al., 1991a; Johnson et al., 1991b; Serdar et al., 1991; Serdar et al., 1994a; Era et al., 2002; EPA, 1992; EPA, 2002a). The results represent numerous species and include results from whole fish and edible tissue from both individual fish and composite samples of multiple fish. Many data used in Figure 4 are from early 1990s sampling of Lake Roosevelt and the upper Columbia River; this was a period when the Columbia River was receiving untreated pulp mill effluent from a Canadian mill. PCDD/F levels in fish from the area have decreased since the pulp mill began treating their wastewater (Serdar et al., 1994a).

Figure 4 shows that the 2002 results fall in the lower 25th percentile of values found in Washington fish. Most all edible tissue sampled for PCDD/Fs in the state exceed the NTR criterion of 0.07 ppt ww for the protection of human health and both of EPA's SV for subsistence fishers (0.032 ppt ww) and recreational fishers (0.256 ppt ww).

Chlorinated Pesticides

Background

Chlorinated pesticides have been used for decades as an insecticide in agricultural and home environments. These compounds have low solubility in water, are not readily metabolized or excreted, are readily stored in fat tissue, and biomagnify to high concentrations in the food web. Many are neurotoxins and are suspected or known carcinogens (EPA, 2000a). Many of these compounds (e.g., DDT, chlordanes, and dieldrin) were banned from use in the United States during the 1970s and 1980s as their hazards became evident. Due to their high persistence, chlorinated pesticides continue to be found in fish and wildlife throughout the world.

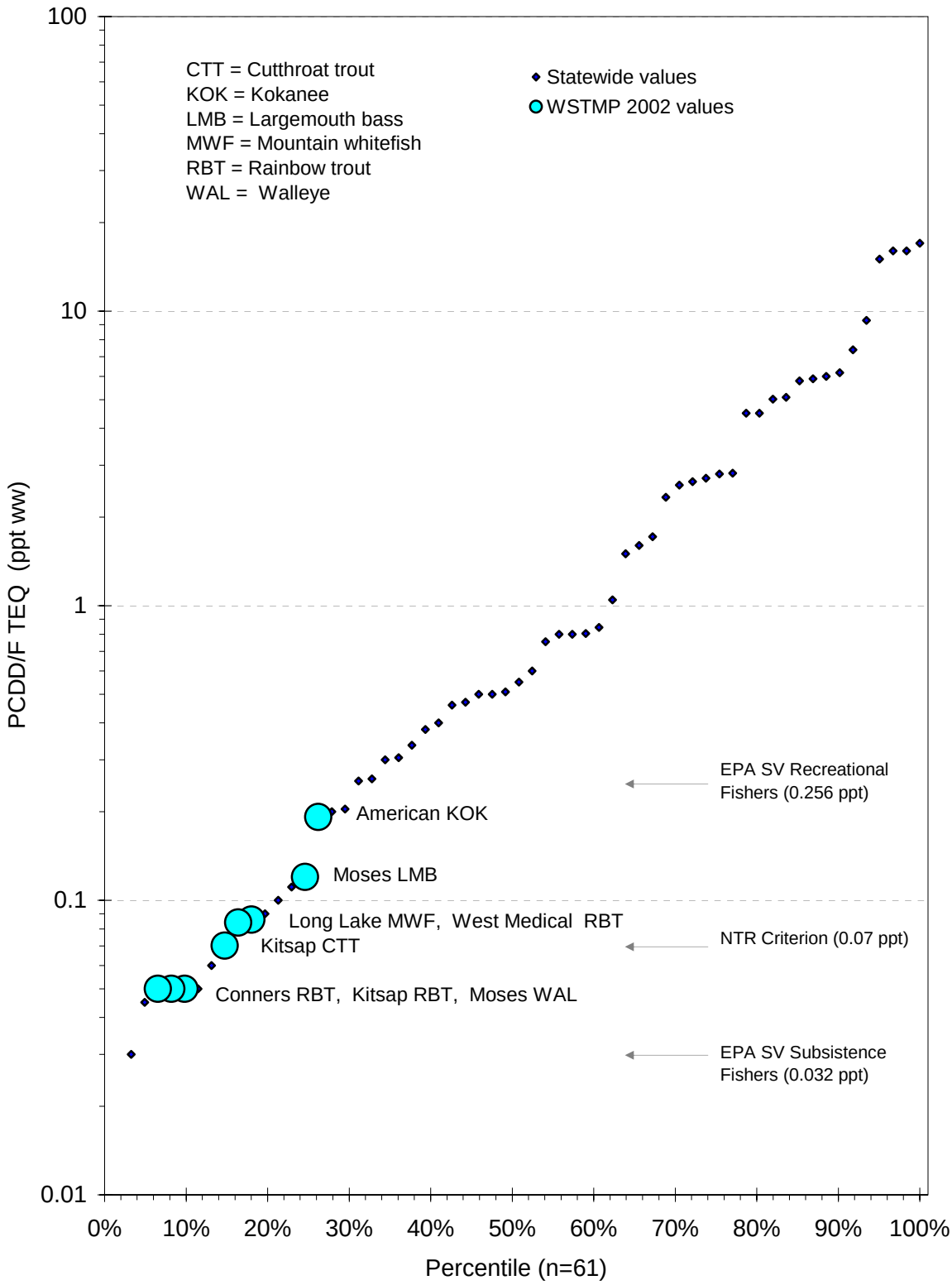

Figure 4. Cumulative Frequency Distribution of PCDD/F TEQs in Fish Tissue.

Human Health Criteria Exceedances

Two chlorinated pesticides exceeded criteria for the protection of human health: total DDT and dieldrin (Table 4 and Appendix D, Table D-2). Total DDT in Moses Lake largemouth bass (16.4 ppb ww) and rainbow trout (30.7 ppb ww) exceeded EPA's SV for carcinogenic effects for subsistence fishers of 14.4 ppb ww. Dieldrin in American Lake kokanee (1.2 ppb ww) exceeded the NTR criterion of 0.65 ppb ww and EPA's SV for carcinogenic effects for subsistence fishers of 0.307 ppb ww.

Several other pesticides were detected with none exceeding any criteria for the protection of human health. The insecticide cis-chlordane was detected in one sample while trans-nonachlor was detected in four samples. Hexachlorobenzene, a fungicide used for wheat and grain seeds since 1984, was detected in American Lake kokanee and Moses Lake rainbow trout. Pentachloroanisole, a metabolic product of pentachlorophenol, was detected in two samples at low levels. One breakdown product of DDT, DDMU, was detected only in largemouth bass from Moses Lake. The insecticide methoxychlor was detected only in Kitsap Lake cutthroat trout and at low levels.

Wildlife Criteria Exceedances

Pesticide concentrations in fish tissue were well below several criteria developed for the protection of wildlife (Table 6). The NAS/NAE (1972) criteria were not exceeded by any samples for any contaminant, nor were criteria developed by the New York DEC for protecting fish-eating wildlife in the Niagara River basin (Newell et al., 1987).

Most pesticides were detected at levels more than ten times lower than criterion. Individually, the pesticides detected in fish tissue likely pose little risk to most wildlife. It is uncertain what the effects of combinations of pesticides would have since little is known about the synergistic effects of these contaminants.

Statewide Comparison

Many of the pesticides found during this study are also among the most commonly detected pesticides found in Washington fish during past efforts of the Washington State Pesticide Monitoring Program (WSPMP) (Davis et al., 1998). For example, total DDT was detected at 97% of the 29 freshwater sites monitored during the WSPMP. Total chlordane was detected in tissues from 93% of the WSPMP sites. Hexachlorobenzene and DDMU were detected at 62% and 66%, respectively, of the WSPMP sites.

To gain a statewide perspective on total DDT, 225 results were compiled from historical studies in Washington (Figure 5). These studies were conducted by Ecology and EPA: Davis and Johnson, 1994; Davis et al., 1995; Davis and Serdar, 1996; Davis et al., 1998; EPA, 1992; EPA, 2002a; EPA, 2002b; Hopkins et al., 1985; Hopkins, 1991; Johnson and Norton, 1990; Johnson, 1997; Rogowski, 2000; Serdar et al., 1994b; Serdar, 1998; Serdar and Davis, 1999; and Serdar, 2003. Results from the 2002 WSTMP fall in the lower 25th percentile of statewide results with the exception of Moses Lake rainbow trout whose result ranks at the 37th percentile.

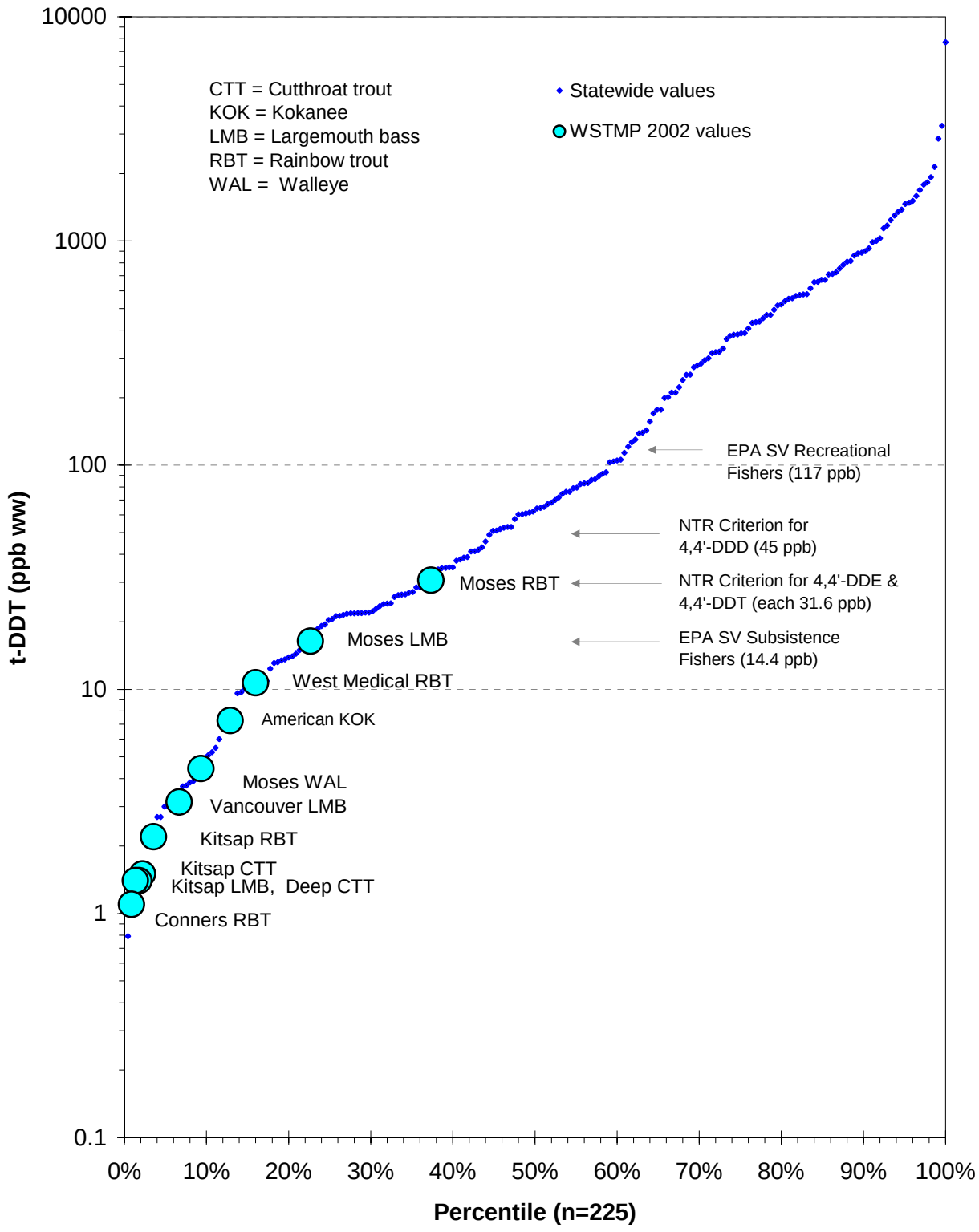

Figure 5. Cumulative Frequency Distribution of Total DDT in Edible Fish Tissue.

Moses Lake fish had the highest levels of DDT in the 2002 sampling and the second highest levels found during Johnson and Norton's 1989 study of ten lakes. Black bullhead collected in 1989 from Moses Lake had a total DDT level of 38 ug/kg ww which is higher than levels found in 2002. The rainbow trout, largemouth bass, and walleye samples collected in 2002 had total DDT levels of 30.7, 16.4, and 4.4 ug/kg ww, respectively. In 1989, no other chlorinated pesticides were detected in the black bullhead from Moses Lake, and no chlorinated pesticides were detected in the rock bass sample from American Lake.

Total DDT levels in Vancouver Lake largemouth bass and common carp collected in 1993 also exceeded NTR criterion and EPA SVs. The total DDT concentration in the largemouth bass sample was 64 ug/kg ww while that in the carp sample was 140 ug/kg ww. Chlordane compounds were also detected in the 1993 samples. Total chlordane in largemouth bass was 4 ug/kg ww and 8 ug/kg ww in carp. Differences between the 1993 and 2002 results in largemouth bass are likely due to various factors as described above for PCB results.

PBDEs

Background

Polybrominated diphenyl ethers (PBDEs) are a group of chemicals used as flame retardants in electronics, plastics, building materials, and textiles. There are 209 theoretically possible congeners of PBDEs. Like PCBs, PBDEs are resistant to physical, chemical, and biologic degradation. The little data available suggest that PBDEs are transported and distributed in the global environment similarly to PCBs. The PBDEs are lipophilic and some appear to bioaccumulate in aquatic environments.

Information on the possible health impacts of PBDEs comes from animal toxicity studies. These studies indicate that PBDEs are associated with developmental neurotoxicity, thyroid hormone disruption, reproductive effects, and liver changes (Darnerud et al., 2001; Birnbaum et al., 2004). Recent studies estimate diet as the main route of exposure to PBDEs for the general public (Harrad et al., 2004).

Due to limited research on the possible consumer health risk from PBDEs, concern remains about the effects of these compounds on humans and biota. PBDEs are the focus of Washington's second Chemical Action Plan to be developed under the state's PBT Initiative (Gallagher, 2000). Currently there are no criteria for PBDEs for the protection of human health or wildlife.

PBDE Detections and Statewide Comparison

Three PBDE congeners were detected in five of 11 tissue samples (Table 3 and Appendix D, Table D-2). Concentrations of the congeners PBDE-47, PBDE-99, and PBDE-100 ranged from 0.84 to 4.3 ppb ww. Summing the values for each site yields total PBDE values that range from 1.2 to 6.84 ppb ww.

Total PBDE values found during the 2002 WSTMP are in the lower 30th percentile of values found statewide (Figure 6). Johnson and Olsen (2001) reported results from 16 freshwater fish tissue samples in Washington which showed a range of total PBDEs of from 1.4 ppb ww in an undeveloped watershed to 1,250 ppb ww in fish from the Spokane River. Fish from the Spokane River have the highest values of PBDEs found in Washington to date. The levels of PBDEs found during the 2002 WSTMP were also lower than PBDEs found in salmon from the Lake Michigan area. Manchester-Neesvig et al. (2001) analyzed steaks from 16 coho and 5 chinook salmon from two tributaries to Lake Michigan. Concentrations ranged from 44.6 to 148 ppb ww with a mean of 80.1 ppb ww.

Darnerud et al. (2001) suggests that the tetra- and penta- forms are more bioavailable in sediment than are the more highly brominated congeners (octa- and deca-brominated diphenyl ethers), and that uptake by aquatic biota is greater for these less brominated compounds. The largest fraction of the total PBDEs reported by Johnson and Olsen were also tetra- and penta- compounds.

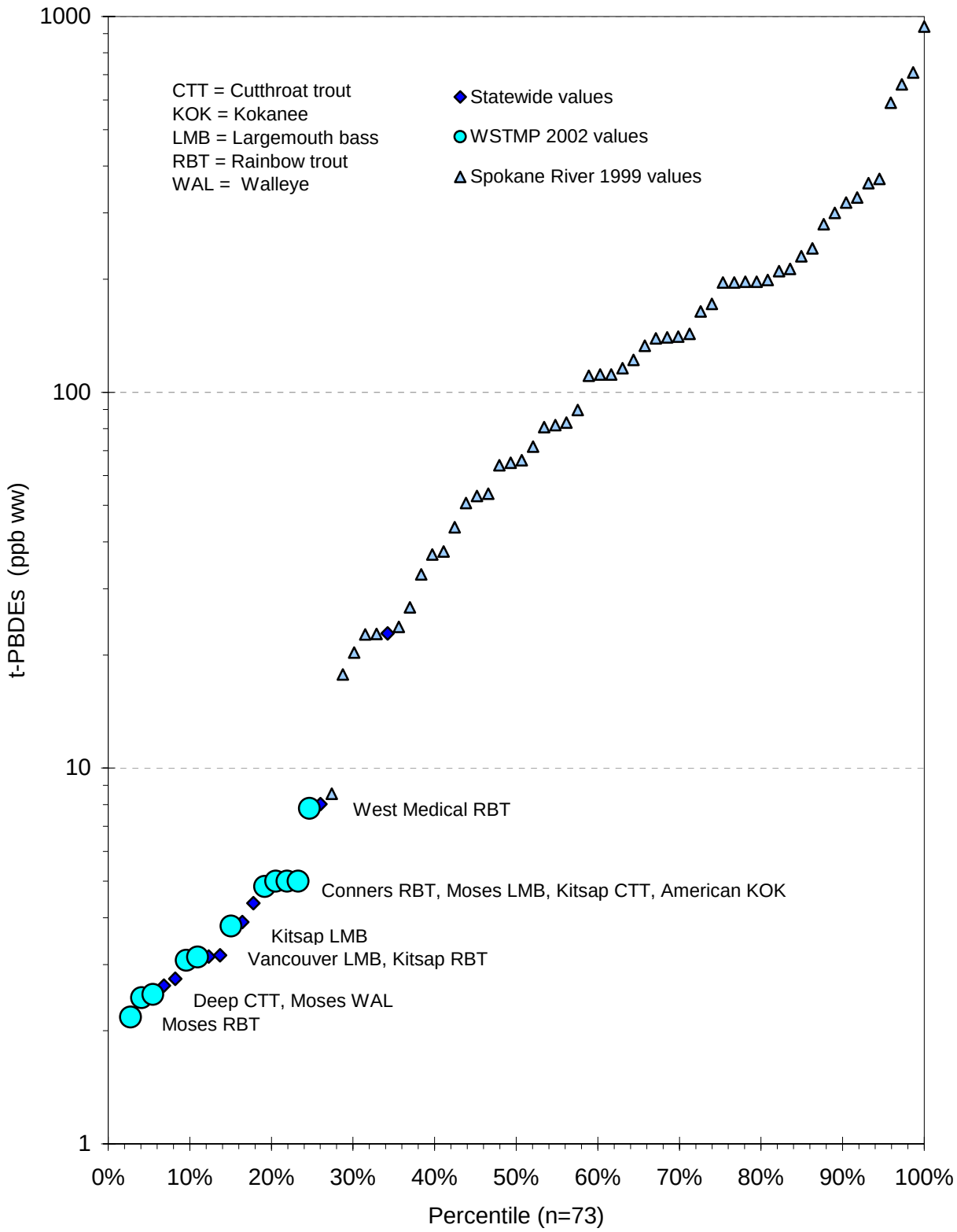

Figure 6. Cumulative Frequency Distribution of Total PBDEs in Edible Fish Tissue.

Water Samples

Results

Results for conventional water quality parameters appeared typical for Washington waters (Appendix E, Table E-1). The relatively high conductivity values for Fry Creek in Aberdeen are likely typical for the site sampled which is tidally influenced. The relatively high total organic carbon results for the 102nd Street Drain on the Long Beach Peninsula are likely due to watershed characteristics: cranberry bogs among low-lying coastal spruce forest. Streamflows were not measured at Peshastin Creek due to hazardous conditions for wading.

Table 7 lists the 17 pesticides that were detected in water samples from nine sites. These pesticides were detected at low levels and low frequencies and included 11 herbicides, four insecticides, one fungicide, and one breakdown product. Pesticides that were most frequently detected included diuron, dichlobenil, bromacil, diazinon, and the herbicide breakdown product 2,6-dichlorobenzamide. These five pesticides have also been detected throughout Washington during past studies: Table 8 shows detection frequencies and range of concentrations for data obtained from Ecology's Environmental Information System (EIM) database at http://apps.ecy.wa.gov/eimreporting/.

Aquatic Life Criteria Exceedances

Some results for some toxic substances could not be compared to Washington's water quality criteria for the protection of aquatic life (WAC 173-201A-040) because quantitation limits were higher than the criteria. Analytes that were not detected at detection limits below water quality criteria were DDT and chlordane compounds, aldrin, chlorpyrifos, dieldrin, endrin, endosulfan, heptachlor, lindane, and parathion.

Results were compared to water quality criteria available from other jurisdictions. Table 9 shows that these criteria were exceeded only by diazinon. Two estimated results for diazinon exceed the chronic criterion of 0.04 ug/L recommended by Menconi and Cox (1994). Levels of other pesticides were well below criteria for the protection of aquatic life.

Diazinon was recently the most widely used pesticide ingredient for application around the home, on lawns, and in gardens. Its wide use resulted in it being one of the leading causes of acute insecticide poisoning for humans and wildlife. This pesticide is highly toxic to birds, mammals, honeybees, and other beneficial insects. It is also highly toxic to freshwater fish and invertebrates following acute exposure. Diazinon is one of the most commonly found pesticides in air, rain, and drinking and surface water.

In December 2000, EPA announced plans to phase out diazinon for indoor uses beginning in March 2001 and for all lawn, garden, and turf uses by December 2003. EPA took this action under the Food Quality Protection Act of 1996. This law requires the review of older organophosphorus pesticides because they pose the greatest potential risk to children. Diazinon is the latest organophosphorous pesticide to be phased out. In August 1999, EPA announced

action against methyl parathion and azinphos methyl to protect children from pesticide residues in food. In December 2000, manufacture of chlorpyrifos (Dursban) for nearly all residential uses was discontinued (EPA, 2000b).

Table 7. Range of Pesticide Levels Detected in Water, WSTMP 2002.

Type	Analyte	Number of Detections	Frequency of Detection	Minimum Value (ug/L)		Maximum Value (ug/L)	
N, H	Diuron	5	21%	0.030	J	0.15	NJ
OP, I	Diazinon	5	21%	0.0055	J	0.05	J
N, B	2,6-dichloro benzamide	4	17%	0.096	J	0.2	J
N, H	Dichlobenil	4	17%	0.013	J	0.089	J
N, H	Bromacil	3	13%	0.013	J	0.047	
OP, I	Dialifor	2	8%	0.019	J	0.12	J
D	Caffeine	2	8%	0.017	J	0.019	J
N, F	Chlorothalonil (Daconil)	1	4%	0.0027	J	0.0027	J
N, H	Atrazine	1	4%	0.0042	J	0.0042	J
N, H	Benefin	1	4%	0.0063	J	0.0063	J
N, H	Ethalfluralin (Sonalan)	1	4%	0.033	J	0.033	J
N, H	Fluridone	1	4%	0.22	J	0.22	J
N, H	Napropamide	1	4%	0.009	J	0.009	J
N, H	Norflurazon	1	4%	0.013	J	0.013	J
N, H	Pronamide (Kerb)	1	4%	0.0063	J	0.0063	J
N, H	Triallate	1	4%	0.17		0.17	
OC, I	Trans-Nonachlor	1	4%	0.0016	J	0.0016	J
OP, I	Tetrachlorvinphos (Gardona)	1	4%	0.0042	J	0.0042	J
D	Acetaminophen	1	4%	0.058	J	0.058	J

N - Nitrogen
OP - Organophosphorus
OC - Organochlorine
D - Drug (included here as additional information)
H - Herbicide
F - Fungicide
I - Insecticide
B - Breakdown product of herbicide dichlobenil

J - The analyte was positively identified. The associated numerical value is an estimate.
NJ - There is evidence that the analyte is present. The associated numerical result is an estimate.

Table 8. Historical Detection Frequency in Washington of the Five Pesticides Most Commonly Detected in Water, WSTMP 2002.

Analyte	Number of Historical Samples	Frequency of Detection	Minimum Value (ug/L)		Maximum Value (ug/L)		Median Value (ug/L)	
2,6-dichlorobenzamide	74	99%	0.0012	J	0.72	J	0.098	J
Diazinon	354	41%	0.0009	NJ	5.7	J	0.056	
Dichlobenil	299	38%	0.0015	J	7.5		0.047	
Bromacil	282	21%	0.003	J	0.67	J	0.033	J
Diuron	268	15%	0.017	NJ	1.2	J	0.087	NJ

J - The analyte was positively identified. The associated numerical value is an estimate.
NJ - There is evidence that the analyte is present. The associated numerical result is an estimate.

Table 9. Water Quality Criteria for the Protection of Aquatic Life for Pesticides Detected in Water Samples, WSTMP 2002.

Analyte	Water Quality Criterion (ug/L)	2002 WSTMP Maximum Value (ug/L)	Reference [1]	Note
Atrazine	2	0.0042 J	MENVIQ, 1990 [2]	Chronic criterion
Atrazine (total and/or dissolved)	0.075	0.0042	Stortelder et al., 1989 [3]	Ecotoxicological value
Chlorothalonil (Daconil)	0.1	0.0027	Norris and Dost, 1981 [4]	Chronic criterion proposed
Chlorothalonil (Daconil)	0.18	0.0027 J	CCREM 1987 [5]	Interim Guideline
Diazinon	0.04	0.05	Menconi and Cox, 1994 [6]	Chronic criterion
Diazinon	0.08	0.05	NYSDEC, 1993 [7]	Chronic criterion
Dichlobenil	37	0.089 J	MENVIQ, 1990 [2]	Chronic criterion
Diuron	1.6	0.15 NJ	OMEE, 1994 [8]	Provincial WQ Guideline
Triallate	0.24	0.17	CCREM 1987 [5]	Interim Guideline

J - The analyte was positively identified. The associated numerical value is an estimate.

NJ - There is evidence that the analyte is present. The associated numerical result is an estimate.

1 - All references below (b-h) as cited in MacDonald, D.D., 1994. A Review of Environmental Quality Criteria and Guidelines for Priority Substances in the Fraser River Basin. MacDonald Environmental Sciences, Limited. Ladysmith, British Columbia.

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6 - Menconi, M. and C. Cox, 1994. Hazard Assessment of the Insecticide Diazinon to Aquatic Organisms in the Sacramento-San Joaquin River System. California Department of Fish and Game, Environmental Services Division. Administrative Report 94-2.

7 - New York State Department of Environmental Conservation, 1993. Technical Guidance for Screening Contaminated Sediments. Division of Fish and Wildlife, Division of Marine Resources. New York, New York

8 - Ontario Ministry of Environment and Energy, 1994. Provincial Water Quality Objectives and Guidelines. Toronto, Ontario.

Conclusions

Fish Tissue Samples

- During this 2002 exploratory monitoring effort, 12 composite samples of edible tissue were analyzed, representing six species collected from eight sites. Levels of PCBs and PCDD/Fs in fish tissue frequently exceeded criteria for the protection of human health while levels of DDT, dieldrin, and mercury showed fewer exceedances. Other contaminants detected in fish tissue were chlordane compounds, hexachlorobenzene, pentachloroanisole, methoxychlor, and PBDEs.

- American Lake kokanee were the most contaminated fish sampled in 2002 with 15 contaminants detected. Three of these exceeded National Toxics Rule (NTR) criteria and EPA screening values for subsistence fishers: total PCBs, dieldrin, and PCDD/Fs. Total PCBs also exceeded EPA screening values for recreational fishers while mercury exceeded EPA screening values for subsistence fishers.

- West Medical Lake rainbow trout contained nine contaminants and had the highest levels of PCBs found in 2002. Total PCBs and PCDD/Fs exceeded NTR criteria and EPA screening values for subsistence fishers. Total PCBs also exceeded EPA screening values for recreational fishers while mercury exceeded EPA screening values for subsistence fishers

- Each of three species of fish from Moses Lake had contaminants that exceeded NTR criteria and/or EPA screening values. Rainbow trout contained nine contaminants with two of these exceeding NTR criteria and EPA screening values (total PCBs and PCDD/Fs). Total DDT also exceeded an EPA screening values for subsistence fishers. Fish tissue data from 1989 also showed DDT levels exceeding the EPA screening values for subsistence fishers. Largemouth bass had six contaminants with total PCBs exceeding NTR criteria with mercury and total DDT exceeding EPA screening values for subsistence fishers. PCDD/Fs were not analyzed in largemouth bass. Walleye had three contaminants detected with total PCBs exceeding an EPA screening value for subsistence fishers. PCDD/Fs were not detected in walleye.

- Each of three species of fish from Kitsap Lake had contaminants that exceeded NTR criteria and/or EPA screening values. Rainbow and cutthroat trout each had six contaminants with total PCBs exceeding NTR criteria and EPA screening values for subsistence fishers. PCDD/Fs in cutthroat trout exceeded NTR criteria and EPA screening values for subsistence fishers. Mercury levels in cutthroat trout exceeded EPA screening values for subsistence fishers. PCDD/Fs were not detected in rainbow trout. Largemouth bass had the highest mercury level of fish sampled in 2002: this concentration of 313 ppb ww exceeded EPA's proposed criterion of 300 ppb ww. Four organic contaminants were found in this bass sample with total PCBs exceeding an EPA screening value for subsistence fishers. PCDD/Fs were not analyzed in this sample.

- Vancouver Lake largemouth bass had five contaminants with total PCBs exceeding NTR criteria and an EPA screening value for subsistence fishers. Mercury levels in this sample exceeded the EPA screening value for subsistence fishers. PCDD/Fs were not analyzed in this sample. Other fish tissue data from 1993 had total PCB and total DDT levels that exceeded NTR criteria and EPA screening values.

- Long Lake mountain whitefish were analyzed only for PCDD/Fs as part of this 2002 study. PCDD/Fs exceeded NTR criteria and EPA screening values for subsistence fishers.

- Deep Lake cutthroat trout and Conners Lake rainbow trout were the least contaminated fish sampled in 2002. These samples showed no PCB detections, and each contained low levels of 4,4'-DDE. No PCDD/Fs were detected in the Conners Lake rainbow trout sample while pentachloroanisole was detected at a low level.

- Criteria for the protection of wildlife were not exceeded in any of the tissue samples.

Water Samples

- Water samples were collected up to three separate times from each of nine sites and analyzed for 115 chlorinated, organophosphorous, and nitrogen pesticides. Seventeen pesticides were detected at low levels and low frequencies. The most frequently detected pesticides included diuron, dichlobenil, bromacil, diazinon, and the herbicide breakdown product 2,6-dichlorobenzamide.

- Two results for diazinon exceeded the chronic criterion for the protection of aquatic life. No other pesticides were detected at levels exceeding water quality criteria.

Recommendations

As a result of this 2002 Washington State Toxics Monitoring Program study, the following recommendations are made:

- Ecology should consider additional fish tissue sampling at sites where criteria for the protection of human health were exceeded. The Washington State Department of Health and local health jurisdictions should be consulted about sampling designs that would help determine whether a fish consumption advisory is warranted.

- The following six lakes should be placed on the state's 303(d) list, Category 5, for the associated contaminant(s):
  - American Lake – PCBs, PCDD/Fs, and dieldrin in kokanee
  - Kitsap Lake – PCBs and PCDD/Fs in cutthroat; PCBs in rainbow trout
  - Long Lake – PCDD/Fs in mountain whitefish
  - Moses Lake – PCBs and PCDD/Fs in rainbow trout; PCBs in largemouth bass
  - Vancouver Lake – PCBs in largemouth bass
  - West Medical Lake – PCBs and PCDD/Fs in rainbow trout

- Future data analyses should characterize spatial patterns for selected contaminants and fish species to provide a more comprehensive view of fish tissue contamination across the state.

- If water sampling is continued, a different approach should be considered in order to increase temporal coverage and lower detection limits. For example, the use of semi-permeable membrane devices (SPMDs) rather than water samples would allow a greater temporal coverage (up to one month) and sensitivity, producing a more representative and useful sample.

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Appendices

A. Sample Site Descriptions
B. Field Sampling Procedures
C. Data Quality Assessment
D. Fish Tissue Sample Data
E. Water Sample Data

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Appendix A

Sample Site Descriptions

Table A-1. Sample Site Descriptions, WSTMP 2002.

Site Name	Latitude [1] (decimal degrees)	Longitude [1] (decimal degrees)	WBID [2]	County	EIM "User Location ID" [3]
Fish					
American Lake	47.1326	122.5631	WA-12-9010	Pierce	AMERICAN-F
Conners Lake	48.7500	119.6614	WA-49-0000	Okanogan	CONNERS-F
Deep Lake	48.8595	117.6036	WA-61-9020	Stevens	DEEP1-F
Kitsap Lake	47.5726	122.7051	WA-15-9150	Kitsap	KITSAP-F
Moses Lake	47.1581	119.3416	WA-41-9250	Grant	MOSES-F
Long Lake (upper)	47.7966	117.5858	WA-54-9040	Stevens	ULL-MHF1
Vancouver Lake	45.6800	122.7196	WA-28-9090	Clark	VANCOUVER-F
West Medical Lake	47.5747	117.7096	WA-43-9160	Spokane	WMED-F
Water					
102nd St. Drain	46.3726	124.0270	WA-24-0020	Pacific	102-ND
Fry Creek	46.9698	123.8510	WA-22-0030	Grays Harbor	FRY
Latah Creek [4]	47.5877	117.4021	WA-56-1010	Spokane	LATAH
Latah Creek [5]	47.3510	117.2464	WA-56-1010	Spokane	LATAH-WAV
Little Deep Creek	47.7972	117.3782	WA-55-1011	Spokane	LITL-DEEP
Matriotti Creek	48.1355	123.1416	WA-18-1012	Clallam	MATRIOTTI
Mercer Creek	47.6030	122.1807	WA-08-2100	King	MERCER
Peshastin Creek	47.5571	120.5825	WA-45-1013	Chelan	PESHASTIN
Tenmile Creek	48.8541	122.5408	WA-01-1012	Whatcom	TENMILE

1 - North American Datum 1983 is the horizontal datum for coordinates. Coordinates for fish tissue samples are in central part of lake while fish were usually collected from many areas of the lake.
2 - Ecology's Water Body Identification Number (WBID).
3 - Site identification as used in Ecology's Environmental Information Management system.
4 - Latah Creek at Hatch Road; also called Hangman Creek
5 - Latah Creek near Waverly; also called Hangman Creek

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Appendix B

Field Sampling Procedures

Fish Tissue Samples

Methods for the collection, handling, and processing of fish tissue samples for analysis were guided by methods described in EPA (2000a). Ecology crews collected fish by electrofishing with a 16' Smith-Root electrofishing boat at all sites except for upper Long Lake where fish were collected by Washington Department of Fish & Wildlife (WDFW) crews. Captured fish were identified to species, and target species were retained while non-target species were released. Retained fish were inspected to ensure that they were acceptable for further processing (e.g., proper size, no obvious damage to tissues, skin intact). Field preparation of individual fish involved:

- Sacrificing the fish by a blow to the head with a dull object.
- Rinsing in ambient water to remove foreign material from their exterior.
- Weighing to the nearest gram.
- Measuring the total length to the nearest millimeter.
- Double-wrapping individuals in foil with a tag identifying the date and location of capture, species, and fish identification number.
- Placing foil-wrapped fish into plastic zip-lock bags.
- Placing the bagged fish on ice in the field and transporting iced fish to the Ecology facilities in Lacey, Washington within 72 hours of collection.
- Transferring fish to dedicated freezer and freezing to -20 degrees C.

Frozen fish were processed at Ecology's Lacey facility on a later date to form samples to be sent to the laboratory for analysis. The edible portion of target species was used for individual and composite samples. For analysis of organic compounds, at least five fish were used to create a composite sample for each site sampled. The processing of fish was as follows:

- Fish were removed from the freezer and partially thawed.
- Scales were removed using the dull side of a fillet knife.
- One or two skin-on fillets were removed from the fish, depending on the fish size and sample mass required for analysis.
- The skin for largemouth bass was removed from fillets because these fish were originally used for a statewide mercury study.
- Fillets were cut into 1-2 cm pieces and passed through a decontaminated Kitchen-Aid® model FGA food grinder two times to allow thorough grinding and homogenization of fillets from individual fish.
- Equal amounts of the ground and homogenized tissue from each fillet were combined and homogenized by mixing in a stainless steel bowl, passing this through the grinder once more, then homogenized a final time.
- At least 90 grams of the composite sample was put into a pre-cleaned, 4-oz, I-Chem series 200 or 300 jar.
- Sample jars were identified with a sample ID code and pre-assigned lab sample number. Extra tissue was archived.
- Sample jars ready for analysis were returned to the freezer until transported to the laboratory.

After fillets were removed from the fish, scales and otoliths were removed for determining the age of individual fish. Scales were mounted on acetate scale cards provided by WDFW biologists while otoliths were stored in plastic trays designed for such work. All aging structures were identified, packaged according to WDFW directions, and then sent to WDFW staff in Olympia, Washington. WDFW later reported the age of individual fish on a spreadsheet or on the returned scale cards. The gender of each fish was determined by opening the abdominal cavity and identifying gonads as testes or ovary.

Water Samples

Water samples for organic contaminant analyses were a composite sample from aliquots collected from three points along a transect in streams. At each quarter-transect point, a US DH-81 rod-mounted sampler with a pre-cleaned, one-liter jar was lowered slowly from the water surface and back to the surface multiple times until filled. The collected sample was then transferred to a pre-cleaned, one-gallon I-Chem jar (Series 200 or 300), and the process was repeated at each transect point until the gallon jar was filled. Samples for TSS and TOC were collected similarly. Filled sample containers were placed on ice and delivered to the laboratory within 24 to 72 hours.

After water samples were collected, temperature, pH, and conductivity were measured in-situ, and streamflow was measured. Temperature and pH were measured with a handheld Orion Model 250A portable pH meter with a Model 9107 low maintenance triode electrode. Conductivity was measured with a Beckman RB-5 portable conductivity meter. Streamflow was determined by measuring depth with a top-set wading rod and measuring velocity with a March-McBirney Model 201 Flowmeter at more than ten points across the stream. Streamflow at the 102nd Street site culvert was determined with either a bucket and stopwatch method, or by measuring velocity and depth at three points along the cross-section at least two feet upstream of the culvert's discharge lip. All instruments were calibrated and operated according to manufacturer's instructions.

Decontamination Procedures

All utensils used for processing tissue samples were cleaned in order to prevent contamination of the sample. Utensils include bowls, knives, and tissue grinding appliances having plastic and stainless steel parts. Equipment contacting water samples during collection included glass jars and Teflon nozzles. All utensils for fish tissue and water sampling were cleaned using the following procedure:

- Soap (Liquinox) and hot water wash
- Tap water rinse
- 10% nitric acid rinse (omitted for water sampling devices)
- Deionized water rinse (omitted for water sampling devices)
- Solvent rinses with pesticide-grade acetone followed by hexane and/or methanol
- Utensils air-dried and then packaged in aluminum foil and plastic bags to prevent contamination

The live well on the electrofishing boat, used to temporarily store fish when captured, was rinsed and scrubbed with ambient water prior to collecting and holding fish. The live well and retrieval nets were cleaned several times during the collection season at Ecology's Lacey facilities using a general boat washing soap followed by thorough rinsing with tap water.

Field Records

Information about each sampling event was recorded in field notebooks. Notes included:

- Date and time
- Sampling personnel
- General sampling location
- Latitude/longitude coordinates of sample site sometimes taken using a Magellan Model 320 Handheld GPS
- General weather conditions
- Method of sampling
- Fish species collected
- Weights and lengths for individual fish specimens
- Results from field measurements such as temperature, pH, conductivity, and streamflow data

Additional information was recorded at the time fish tissue samples were processed and submitted for laboratory analysis:

- Fish identification number
- Preassigned laboratory sample number
- Date of resection
- Types of aging structures retained and their identification data
- Sex of specimen
- Which fillet(s) removed
- Weight of fillet before grinding
- Weight of sample transferred to sample jar
- Whether an archive sample was retained and stored at Ecology's Lacey facility
- Other observations or notes about processing the sample

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Appendix C

Data Quality Assessment

Data Quality for Fish Tissue Sample Results

Lipids

The precision estimates for field and laboratory duplicate samples for lipids analyzed by Ecology's Manchester Environmental Laboratory (MEL) met measurement quality objectives described in the project plan (Seiders and Yake, 2001) and objectives met by MEL (Daiker et al., 2003). Inter-laboratory precision was estimated using results from MEL and Pace Analytical, Inc. Precision estimates for these results were good, ranging from less than 1% to 15% relative standard deviation (RSD). Table C-1 shows results from duplicate samples with precision expressed in terms of RSD and as relative percent difference (RPD).

Results from Pace Analytical's analysis of a field replicate showed poor precision with a RSD of 35%. It is likely that the duplicate result of 2.69% lipids is low for some reason such as poor homogeneity of the sample. The result of 4.47% lipids is much closer to the results obtained by MEL for this sample.

Pesticides/PCBs/PBDEs

Quality control and quality assurance data from laboratories were reviewed and indicated that analytical systems performance was adequate with most data meeting objectives for quality control. Some data were qualified due to challenges encountered in analyses of the samples, and all results were useable as qualified. Quality control procedures included analysis of method blanks, calibration standards, control standards, matrix spikes, matrix spike duplicates, surrogate spikes, laboratory duplicates, and field duplicates. Holding times for all analyses were met except sample extract holding times in some cases where samples were re-analyzed.

The case narrative for the pesticide and PCB analyses describes in detail which samples were affected by problems with poor recovery performance for some calibration standards, control standards, surrogates, and matrix spikes (Mandjikov, 2004). Some samples were re-extracted and re-analyzed with the result being that many values were qualified as estimates (J, NJ, or UJ). Some PCB Aroclors detected in the samples were described as weathered because of poor matching to reference standards; these results were qualified as estimated values (NJ).

Matrix spike recoveries of most analytes were within limits (Table C-2). For many analytes that were outside of limits, samples were re-extracted and re-analyzed. Recoveries of these analytes during the re-analysis were within limits yet results were still qualified as estimates. Results from the matrix spike duplicate showed good precision with most RSDs being less than 5%.

Duplicate samples met precision criteria defined by MEL and the project plan. Laboratory precision, expressed as the RPD, met MEL's criteria of being less than 20%. Results from the field duplicate sample met the project plan's target of 28% RSD for the compounds that were detected. The field duplicate for tissue was a split of the field-processed tissue of the composite sample and not an

entirely different group of fish collected from the same location. Table C-3 shows results for laboratory and field duplicate analyses for pesticides, PCBs, PBDEs, and mercury.

Mercury

Results from quality control and quality assurance practices for fish tissue samples indicate that the analytical system performed adequately with data meeting objectives for quality control. Quality control procedures included analysis of method blanks, control standards, matrix spikes, matrix spike duplicates, and field duplicates. Results from the analyses of blanks, standards, matrix spikes, and matrix spike duplicates met all acceptance criteria established by MEL (Momohara, 2002a). Precision of field duplicate analyses was good with a RSD of 3%
(Table C-3).

Tissue samples were analyzed within seven to ten months of collection. Bloom (1995) states that biota samples for mercury analysis may be stored indefinitely when frozen. The USGS's NAWQA program uses six months as a holding time (Crawford and Luoma, 1993). Mercury results were not qualified as estimates due to samples exceeding Ecology and EPA's 28-day holding time which appears to be based on water and sediment matrices. The 28-day holding time may be overly conservative for fish tissue kept frozen at -20 C.

PCDD/Fs

The analytical report and data generated by Pace Analytical Incorporated, of Minneapolis, Minnesota, were reviewed by MEL and then forwarded as part of the case narrative to the project manager (Feddersen, 2003). The data review included examination of holding times, blank results, calibration, internal standard recoveries, ion abundance ratios, and precision and recovery limits. Quality controls indicated the analytical system performed well with few data needing qualification. One sample exceeded the one-year holding time for dioxin analyses, and results were qualified as estimates: upper Long Lake mountain whitefish, sample ID 0187212. This sample consisted of archived tissue collected as part of a different study investigating PCBs in Long Lake (Jack and Roose, 2002).

Some of Pace Analytical's data qualifiers were amended by MEL in order to remain consistent with MEL's reporting conventions (e.g., qualifiers used for estimated values or non-detects). Lab results for PCCD/Fs were reported as wet weight for fish tissue samples. Samples were prepared and analyzed according to EPA Method 1613b; the lipid content of each sample was also determined.

Reporting limits did not meet the desired limits defined in the project plan (0.1 – 1.0 pptr) due to an inadequate amount of tissue sample used for extraction (10 g vs 25 g). Upon request, Pace Analytical reviewed the raw data to see if lower reporting limits could be justified and reported results to the lowest limit of detection. Where these results were reported below the quantitation limit, results were qualified as estimates (J or UJ).

Results from laboratory and field duplicate samples are shown in Table C-4. Only one congener was detected in a duplicate sample: 2,3,7,8-TCDF in the Moses Lake rainbow trout sample and field duplicate. The RSD of 13% for this result met the precision target defined in the project plan (RSD less than or equal to 28%).

Data Quality for Water Sample Results

Results from quality control practices for water samples indicate that the analytical system performed adequately and that data are useable as qualified. Quality control procedures included analysis of method blanks, matrix spikes, surrogate recoveries, and field duplicates. Laboratory duplicate analyses were not performed. Case narratives for each batch of samples described analytical performance and reasons for qualifying some sample results as estimates (Perez, 2002). Holding times for all analyses were met. No target analytes were found in blank samples. The recoveries of some surrogate compounds, matrix spikes, and laboratory control samples were low which led to some results being qualified as estimates (J). Measurement quality objectives described in the project plan were met.

Precision for the conventional parameters was good (Table C-5). Results from matrix spike and spike duplicate (Table C-6) indicate good precision with an average RSD of 10%. Results from the field duplicate sample show good precision for 2,6-dichlorobenzamide, the only compound detected (Table C-7).

Table C-1. Intra- and Inter-laboratory Duplicate Results for Lipids in Fish Tissue, WSTMP 2002.

Intra-laboratory duplicate sample results (MEL)

Site	Species	MEL Sample ID (03-)	MEL sample result (% lipids)	Field dup result* (% lipids)	Lab dup result* (% lipids)	RSD for field dup	RSD for lab dup	RPD for field dup	RPD for lab dup
Kitsap	CTT	187201	1.79	-	-	-	-	-	-
Kitsap	RBT	187204	1.76	-	-	-	-	-	-
American	KOK	187203	8.13	-	-	-	-	-	-
Moses	WAL	187211	1.24	-	-	-	-	-	-
Moses	RBT	187208	4.39	4.27	4.15	2%	2%	3%	3%
Conners	RBT	187210	3.31	-	-	-	-	-	-
West Medical	RBT	187205	2.36	-	-	-	-	-	-

Inter-laboratory duplicate sample results (MEL and Pace Analytical, Inc.)

Site	Species	MEL Sample ID (03-)	MEL sample result (% lipids)	Pace result (% lipids)	Pace field dup result* (% lipids)	RSD for inter-lab results	RSD for field dup	RPD for inter-lab results	RPD for field dup
Kitsap	CTT	187201	1.79	1.92	-	5%	-	7%	-
Kitsap	RBT	187204	1.76	2.17	-	15%	-	21%	-
American	KOK	187203	8.13	8.47	-	3%	-	4%	-
Moses	WAL	187211	1.24	1.25	-	1%	-	1%	-
Moses	RBT	187208	4.39	4.47	2.69	1%	35%	2%	50%
Conners	RBT	187210	3.31	3.06	-	6%	-	8%	-
West Medical	RBT	187205	2.36	2.37	-	0%	-	0%	-

* = MEL Lab ID 03187209
MEL = Manchester Environmental Laboratory
RSD = relative standard deviation
RPD = relative percent difference

Table C-2. Matrix Spike and Spike Duplicate Results for Pesticides, PCBs, and PBDEs in Fish Tissue, WSTMP 2002.

Analyte	Matrix Spike 1 (% recovery)	Matrix Spike 2 (% recovery)	RSD of recovery	RPD of recovery	Note
Chlorinated Pesticides					
2,4'-DDD	90	91	1%	1%	
2,4'-DDE	82	83	1%	1%	
2,4'-DDT	70	69	1%	1%	
4,4'-DDD	85	88	2%	3%	
4,4'-DDE	73	77	4%	5%	rex
4,4'-DDT	88	81	6%	8%	
Aldrin	50	49	1%	2%	
Alpha-BHC	56	57	1%	2%	
Beta-BHC	85	89	3%	5%	
Chlorpyriphos	0	35	141%	200%	
Cis-Chlordane (Alpha-Chlordane)	77	77	0%	0%	rex
Cis-Nonachlor	83	84	1%	1%	
Dacthal (DCPA)	103	98	4%	5%	
Delta-BHC	9	9	0%	0%	rex
Dieldrin	93	92	1%	1%	rex
Endosulfan I	64	64	0%	0%	rex
Endosulfan II	70	70	0%	0%	
Endosulfan Sulfate	31	32	2%	3%	
Endrin	60	60	0%	0%	
Endrin Aldehyde	18	21	11%	15%	rex
Endrin Ketone	77	72	5%	7%	
Heptachlor	22	21	3%	5%	
Heptachlor Epoxide	81	81	0%	0%	rex
Hexachlorobenzene	33	31	4%	6%	rex
Lindane	70	73	3%	4%	
Methoxychlor	96	106	7%	10%	
Mirex	124	123	1%	1%	
Oxychlordane	78	76	2%	3%	
Pentachloroanisole	48	49	1%	2%	
Trans-Chlordane (Gamma)	87	88	1%	1%	
Trans-Nonachlor	77	79	2%	3%	
mean value	67	69	7%	10%	
PCBs					
PCB-1016	69	68	1%	1%	
PCB-1260	88	88	0%	0%	
mean value	79	78	1%	1%	
PBDEs					
PBDE-100 (2,2',4,4',6-pentaBDE)	68	38	40%	57%	
PBDE-153 (2,2',4,4',5,5'-hexaBDE)	61	62	1%	2%	
PBDE-154 (2,2',4,4',5,6'-hexaBDE)	57	57	0%	0%	
PBDE-47 (2,2',4,4'-tetraBDE)	56	55	1%	2%	
PBDE-99 (2,2',4,4',5-pentaBDE)	61	58	4%	5%	
mean value	61	54	9%	13%	

rex - from second extraction of sample
Matrix spike done on MEL sample ID 03187210, Conners Lake rainbow trout.

Table C-3. Duplicate Analyses Results for Mercury, Pesticides, PCBs, and PBDEs in Fish Tissue, WSTMP 2002.

Analyte	Sample 02187208 result (ug/kg ww)		Field dup 02187209 result (ug/kg ww)		RSD of field dup	RPD of field dup	Lab dup 02187209 result (ug/kg ww)		RSD of lab dup	RPD of lab dup
Mercury	25		26		3%	4%				
Chlorinated Pesticides										
2,4'-DDD	0.87	U	0.94	U			0.94	U		
2,4'-DDE	1.8		1.8		0%	0%	2.3		17%	24%
2,4'-DDT	0.87	U	0.94	U			0.94	U		
4,4'-DDD	5.9		5.8		1%	2%	5.3		6%	9%
4,4'-DDE	23		24		3%	4%	25		3%	4%
4,4'-DDT	0.87	U	0.94	U			0.94	U		
Aldrin	0.49	UJ	0.52	UJ			0.53	UJ		
Alpha-BHC	0.87	U	0.94	U			0.94	U		
Beta-BHC	0.87	U	0.94	U			0.94	U		
Chlorpyriphos	0.87	UJ	0.94	UJ			0.94	UJ		
Cis-Chlordane (Alpha-Chlordane)	0.87	U	0.94	U			0.94	U		
Cis-Nonachlor	0.87	U	0.94	U			0.94	U		
Dacthal (DCPA)	0.87	U	0.94	U			0.94	U		
DDMU	2.9	UJ	3	UJ			3.8	UJ		
Delta-BHC	0.87	UJ	0.94	UJ			0.94	UJ		
Dieldrin	0.87	U	0.94	U			0.94	U		
Endosulfan I	0.87	U	0.94	U			0.94	UJ		
Endosulfan II	0.87	UJ	0.94	UJ			0.94	UJ		
Endosulfan Sulfate	0.87	UJ	0.94	UJ			0.94	UJ		
Endrin	0.87	U	0.94	U			0.94	U		
Endrin Aldehyde	0.87	UJ	0.94	UJ			0.94	UJ		
Endrin Ketone	0.87	UJ	0.94	UJ			0.94	UJ		
Heptachlor	0.49	UJ	0.52	UJ			0.53	UJ		
Heptachlor Epoxide	0.87	U	0.94	U			0.94	U		
Hexachlorobenzene	0.41	J	0.5	J	14%	20%	0.68	J	22%	31%
Lindane	0.87	U	0.94	U			0.94	U		
Methoxychlor	0.87	U	0.94	U			0.94	UJ		
Mirex	0.49	U	0.52	U			0.53	U		
Oxychlordane	0.87	U	0.94	U			0.94	U		
Pentachloroanisole	0.87	UJ	0.94	UJ			0.94	U		
Toxaphene	8.7	U	9.4	U			9.4	U		
Trans-Chlordane (Gamma)	0.87	U	0.94	U			0.94	U		
Trans-Nonachlor	0.54		0.55		1%	2%	0.64		11%	15%
PCBs										
PCB-1016	4.9	U	5.2	U			5.3	U		
PCB-1221	4.9	U	5.2	U			5.3	U		
PCB-1232	4.9	U	5.2	U			5.3	U		
PCB-1242	4.9	U	5.2	U			5.3	U		
PCB-1248	4.9	U	5.2	U			5.3	U		
PCB-1254	9		9.5		4%	5%	11		10%	15%
PCB-1260	2.8	NJ	3.2	J	9%	13%	3.1	NJ	2%	3%

Analyte	Sample 02187208 result (ug/kg ww)		Field dup 02187209 result (ug/kg ww)		RSD of field dup	RPD of field dup	Lab dup 02187209 result (ug/kg ww)		RSD of lab dup	RPD of lab dup
PCB-1262	4.9	U	5.2	U			5.3	U		
PCB-1268	4.9	U	5.2	U			5.3	U		
PBDEs										
PBDE-100 (2,2',4,4',6-pentaBDE)	0.87	U	0.94	U			0.94	U		
PBDE-153 (2,2',4,4',5,5'-hexaBDE)	0.87	U	0.94	U			0.94	U		
PBDE-154 (2,2',4,4',5,6'-hexaBDE)	0.87	U	0.94	U			0.94	U		
PBDE-47 (2,2',4,4'-tetraBDE)	0.87	U	0.94	U			0.94	U		
PBDE-99 (2,2',4,4',5-pentaBDE)	0.87	U	0.94	U			0.94	U		
Mean value					4%	6%			10%	14%

Duplicate analyses for MEL sample IDs 03187208 and 03187209, Moses Lake rainbow trout.

U - The analyte was not detected at or above the reported result.

UJ - The analyte was not detected at or above the reported estimated result.

NJ - There is evidence that the analyte is present. The associated numerical result is an estimate.

Table C-4. Duplicate Analyses Results for PCDD/F in Fish Tissue, WSTMP 2002.

Site & species:	Kitsap CTT (sample)		Kitsap CTT (lab dup)		RSD for lab dup	RPD for lab dup	Moses RBT (sample)		Moses RBT (field dup)		RSD for field dup	RPD for field dup
MEL Sample ID:	02187201		02187201				02187208		02187209			
Analyte	(ppt ww)		(ppt ww)				(ppt ww)		(ppt ww)			
1,2,3,4,6,7,8,9-OCDD	1.20	UJ	1.60	NJ	nd	nd	0.82	UJ	0.94	UJ	nd	nd
1,2,3,4,6,7,8,9-OCDF	0.97	UJ	0.61	UJ	nd	nd	0.73	UJ	0.57	UJ	nd	nd
1,2,3,4,6,7,8-HpCDD	1.50	UJ	0.69	UJ	nd	nd	0.67	UJ	0.73	UJ	nd	nd
1,2,3,4,6,7,8-HpCDF	0.41	UJ	0.62	UJ	nd	nd	0.31	UJ	0.48	UJ	nd	nd
1,2,3,4,7,8,9-HpCDF	0.60	UJ	0.81	UJ	nd	nd	0.36	UJ	0.44	UJ	nd	nd
1,2,3,4,7,8-HxCDD	0.78	UJ	0.54	UJ	nd	nd	0.63	UJ	0.47	UJ	nd	nd
1,2,3,4,7,8-HxCDF	0.36	UJ	0.51	UJ	nd	nd	0.33	UJ	0.45	UJ	nd	nd
1,2,3,6,7,8-HxCDD	0.80	UJ	0.70	UJ	nd	nd	0.59	UJ	0.66	UJ	nd	nd
1,2,3,6,7,8-HxCDF	0.35	UJ	0.95	UJ	nd	nd	0.31	UJ	0.39	UJ	nd	nd
1,2,3,7,8,9-HxCDD	0.74	UJ	0.43	UJ	nd	nd	0.42	UJ	0.58	UJ	nd	nd
1,2,3,7,8,9-HxCDF	0.50	UJ	0.57	UJ	nd	nd	0.43	UJ	0.42	UJ	nd	nd
1,2,3,7,8-PeCDD	0.97	UJ	0.89	UJ	nd	nd	0.47	UJ	0.62	UJ	nd	nd
1,2,3,7,8-PeCDF	0.85	UJ	0.76	UJ	nd	nd	0.48	UJ	0.41	UJ	nd	nd
2,3,4,6,7,8-HxCDF	0.37	UJ	0.52	UJ	nd	nd	0.33	UJ	0.41	UJ	nd	nd
2,3,4,7,8-PeCDF	0.60	UJ	0.49	UJ	nd	nd	0.44	UJ	0.53	UJ	nd	nd
2,3,7,8-TCDD	0.78	UJ	0.68	UJ	nd	nd	0.68	UJ	0.49	UJ	nd	nd
2,3,7,8-TCDF	0.54	UJ	0.70	J	nd	nd	1.20		1.00		13%	18%

nd - Not detected

UJ - The analyte was not detected at or above the reported estimated result.

NJ - There is evidence that the analyte is present. The associated numerical result is an estimate.

J - The analyte was positively identified. The associated numerical value is an estimate.

Table C-5. Field and Laboratory Duplicate Results for Water Sample Conventional Parameters, WSTMP 2002.

MEL Sample ID	Sample result (mg/L)	Lab dup result (mg/L)	Field dup result (mg/L) [1]	RSD		RPD		Site
				lab dup	field dup	lab dup	field dup	
Total Organic Carbon (TOC)								
02348048	8.4	-	8.5	-	1%	-	1%	102nd St. Drain
02348040	4.8	4.7	-	1%	-	2%	-	Latah Creek nr Waverly
02258050	4.5	4.4	-	2%	-	2%	-	Latah Creek nr Waverly
02258057	3.5	3.6	-	2%	-	3%	-	Fry Creek
02218050	4.2	4.6	-	6%	-	9%	-	Latah Creek at Hatch Rd.
02218057	2.3	2.4	-	3%	-	4%	-	Fry Creek
Total Suspended Solids (TSS)								
02348048	1 U	2	2	47%	0%	67%	67%	102nd St. Drain
02258055	13	13	-	0%	-	0%	-	Mercer Creek
02218053	3	3	-	0%	-	0%	-	Tenmile Creek

1 - Field dup was MEL sample ID 02348044

Table C-6. Matrix Spike and Spike Duplicate Results for Pesticides in Water, WSTMP 2002.

Analyte	Matrix Spike 1 (% recovery)	Matrix Spike 2 (% recovery)	RSD	RPD
Nitrogen Compounds				
Alachlor	93	78	12%	18%
Atrazine	106	57	43%	60%
Bromacil	93	79	12%	16%
Diphenamid	85	73	11%	15%
Dichlobenil	79	83	3%	5%
Ethalfluralin (Sonalan)	60	44	22%	31%
Fluridone	149	142	3%	5%
Metolachlor	104	93	8%	11%
Metribuzin	92	81	9%	13%
Napropamide	99	80	15%	21%
Norflurazon	114	106	5%	7%
Oxyfluorfen	234	224	3%	4%
Pendimethalin	117	108	6%	8%
Prometryn	94	77	14%	20%
Pronamide (Kerb)	101	88	10%	14%
Propachlor (Ramrod)	87	69	16%	23%
Simazine	89	71	16%	23%
Tebuthiuron	101	85	12%	17%
Terbacil	81	71	9%	13%
Treflan (Trifluralin)	89	60	28%	39%
mean value	103	88	13%	18%
Organophosphorus Compounds				
Azinphos (Guthion)	56	52	5%	7%
Carbophenothion	56	54	3%	4%
Chlorpyrifos	57	52	6%	9%
Demeton-O	94	82	10%	14%
Demeton-S	72	64	8%	12%
Disulfoton (Di-Syston)	60	56	5%	7%
EPN	74	64	10%	14%
Ethion	58	55	4%	5%
Fenitrothion	85	77	7%	10%
Fonofos	137	126	6%	8%
Malathion	62	56	7%	10%
Merphos (1 & 2)	76	71	5%	7%
Methyl Chlorpyrifos	61	56	6%	9%
Sulfotepp	68	64	4%	6%
mean value	73	66	6%	9%
Organochlorine Compounds				
4,4'-DDD	125	125	0%	0%
4,4'-DDE	98	92	4%	6%
4,4'-DDT	0	0		
Aldrin	61	44	23%	32%
alpha-BHC	90	87	2%	3%
beta-BHC	40	35	9%	13%

Analyte	Matrix Spike 1 (% recovery)	Matrix Spike 2 (% recovery)	RSD	RPD
cis-Chlordane (alpha-Chlordane)	116	106	6%	9%
delta-BHC	115	110	3%	4%
Dieldrin	102	96	4%	6%
Endosulfan I	111	96	10%	14%
Endosulfan II	98	92	4%	6%
Endosulfan Sulphate	123	104	12%	17%
Endrin	138	130	4%	6%
Endrin Aldehyde	126	120	3%	5%
Endrin Ketone	0	0		
gamma-BHC (Lindane)	167	159	3%	5%
Heptachlor	56	41	22%	31%
Heptachlor Epoxide	103	96	5%	7%
Methoxychlor	23	60	63%	89%
trans-Chlordane (gamma)	88	84	3%	5%
mean value	89	84	10%	14%

MEL sample ID 02258057 was from Fry Creek, 6/19/02.

Table C-7. Field Duplicate Results for Pesticides in Water Samples, WSTMP 2002.

Analyte	Result 02348044 (ug/L)		Result 02348048 (ug/L)		RSD	RPD	Analyte	Result 02348044 (ug/L)		Result 02348048 (ug/L)		RSD	RPD
2,4'-DDD	0.012	U	0.012	U	-	-	Ethoprop	0.017	U	0.017	U	-	-
2,4'-DDE	0.012	U	0.012	U	-	-	Fenamiphos	0.031	U	0.031	U	-	-
2,4'-DDT	0.012	U	0.012	U	-	-	Fenarimol	0.063	U	0.063	U	-	-
4,4'-DDD	0.012	U	0.012	U	-	-	Fenitrothion	0.015	U	0.015	U	-	-
4,4'-DDE	0.012	U	0.012	U	-	-	Fensulfothion	0.021	U	0.021	U	-	-
4,4'-DDT	0.012	U	0.012	U	-	-	Fenthion	0.015	U	0.015	U	-	-
Abate (Temephos)	0.13	U	0.13	U	-	-	Fluridone	0.13	UJ	0.13	UJ	-	-
Alachlor	0.075	U	0.075	U	-	-	Fonofos	0.013	U	0.013	U	-	-
Aldrin	0.012	U	0.012	U	-	-	Gamma-Chlordene	0.012	U	0.012	U	-	-
Alpha-BHC	0.012	U	0.012	U	-	-	Heptachlor	0.012	U	0.012	U	-	-
Alpha-Chlordene	0.012	U	0.012	U	-	-	Heptachlor Epoxide	0.012	U	0.012	U	-	-
Ametryn	0.021	U	0.021	U	-	-	Hexazinone	0.031	U	0.031	U	-	-
Atraton	0.031	U	0.031	U	-	-	Imidan	0.023	U	0.023	U	-	-
Atrazine	0.021	U	0.021	U	-	-	Kelthane	0.047	U	0.047	U	-	-
Azinphos (Guthion)	0.033	U	0.033	U	-	-	Lindane	0.012	U	0.012	U	-	-
Azinphos Ethyl	0.033	U	0.033	U	-	-	Malathion	0.017	U	0.017	U	-	-
Benefin	0.031	U	0.031	U	-	-	Merphos (1 & 2)	0.025	U	0.025	U	-	-
Benzamide, 2,6-dichloro-	0.21	J	0.17	J	15%	21%	Metalaxyl	0.13	U	0.13	U	-	-
Beta-BHC	0.012	U	0.012	U	-	-	Methoxychlor	0.012	U	0.012	U	-	-
Bolstar (Sulprofos)	0.015	U	0.015	U	-	-	Methyl Chlorpyrifos	0.017	U	0.017	U	-	-
Bromacil	0.083	U	0.083	U	-	-	Methyl Paraoxon	0.038	U	0.038	U	-	-
Butachlor	0.13	U	0.13	U	-	-	Methyl Parathion	0.015	U	0.015	U	-	-
Butylate	0.042	U	0.042	U	-	-	Metolachlor	0.083	U	0.083	U	-	-
Captafol	0.058	U	0.058	U	-	-	Metribuzin	0.021	U	0.021	U	-	-
Captan	0.032	U	0.032	U	-	-	Mevinphos	0.021	U	0.021	U	-	-
Carbophenothion	0.021	U	0.021	U	-	-	MGK264	0.17	U	0.17	U	-	-
Carboxin	0.13	U	0.13	U	-	-	Mirex	0.012	U	0.012	U	-	-
Chlorothalonil (Daconil)	0.05	U	0.05	U	-	-	Molinate	0.042	U	0.042	U	-	-
Chlorpropham	0.083	U	0.083	U	-	-	Napropamide	0.063	U	0.063	U	-	-
Chlorpyriphos	0.017	U	0.017	U	-	-	Norflurazon	0.042	U	0.042	U	-	-
Cis-Chlordane (Alpha-Chlordane)	0.012	U	0.012	U	-	-	Oxychlordane	0.012	U	0.012	U	-	-
Cis-Nonachlor	0.012	U	0.012	U	-	-	Oxyfluorfen	0.083	UJ	0.083	UJ	-	-
Coumaphos	0.025	U	0.025	U	-	-	Parathion	0.017	U	0.017	U	-	-
Cyanazine	0.031	U	0.031	U	-	-	Pebulate	0.042	U	0.042	U	-	-
Cycloate	0.042	U	0.042	U	-	-	Pendimethalin	0.031	U	0.031	U	-	-
DDMU	0.012	U	0.012	U	-	-	Phorate	0.015	U	0.015	U	-	-
Delta-BHC	0.012	U	0.012	U	-	-	Phosphamidon (mixed isomers)	0.05	U	0.05	U	-	-
Demeton-O	0.015	U	0.015	U	-	-	Profluralin	0.05	U	0.05	U	-	-
Demeton-S	0.015	U	0.015	U	-	-	Prometon (Pramitol 5p)	0.021	U	0.021	U	-	-
Di-allate (Avadex)	0.15	U	0.15	U	-	-	Prometryn	0.021	U	0.021	U	-	-
Diazinon	0.017	U	0.017	U	-	-	Pronamide (Kerb)	0.083	U	0.083	U	-	-
Dichlobenil	0.042	U	0.042	U	-	-	Propachlor (Ramrod)	0.05	U	0.05	U	-	-
Dichlorvos (DDVP)	0.017	U	0.017	U	-	-	Propazine	0.021	U	0.021	U	-	-

Analyte	Result 02348044 (ug/L)		Result 02348048 (ug/L)		RSD	RPD	Analyte	Result 02348044 (ug/L)		Result 02348048 (ug/L)		RSD	RPD
Dieldrin	0.012	U	0.012	U	-	-	Propetamphos	0.042	U	0.042	U	-	-
Dimethoate	0.017	U	0.017	U	-	-	Ronnel	0.015	U	0.015	U	-	-
Dioxathion	0.035	U	0.035	U	-	-	Simazine	0.021	U	0.021	U	-	-
Diphenamid	0.063	U	0.063	U	-	-	Sulfotepp	0.013	U	0.013	U	-	-
Disulfoton (Di-Syston)	0.013	U	0.013	U	-	-	Tebuthiuron	0.031	U	0.031	U	-	-
Diuron	0.13	U	0.13	U	-	-	Terbacil	0.063	U	0.063	U	-	-
Endosulfan I	0.012	U	0.012	U	-	-	Terbutryn (Igran)	0.021	U	0.021	U	-	-
Endosulfan II	0.012	U	0.012	U	-	-	Tetrachlorvinphos (Gardona)	0.042	U	0.042	U	-	-
Endosulfan Sulfate	0.012	U	0.012	U	-	-	Trans-Chlordane (Gamma)	0.012	U	0.012	U	-	-
Endrin	0.012	U	0.012	U	-	-	Trans-Nonachlor	0.012	U	0.012	U	-	-
Endrin Aldehyde	0.012	U	0.012	U	-	-	Treflan (Trifluralin)	0.031	U	0.031	U	-	-
Endrin Ketone	0.012	U	0.012	U	-	-	Triadimefon	0.054	U	0.054	U	-	-
EPN	0.021	U	0.021	U	-	-	Triallate	0.063	U	0.063	U	-	-
Eptam	0.042	U	0.042	U	-	-	Tribufos (DEF)	0.029	U	0.029	U	-	-
Ethalfluralin (Sonalan)	0.031	U	0.031	U	-	-	Vernolate	0.042	U	0.042	U	-	-
Ethion	0.015	U	0.015	U	-	-							

MEL Sample IDs 02348044 and 02348048 were from 102nd Street Drain, 8/21/02.

J - The analyte was positively identified. The associated numerical value is an estimate.

U - The analyte was not detected at or above the reported result.

UJ - The analyte was not detected at or above the reported estimated result.

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Appendix D

Fish Tissue Sample Data

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Table D-1. Field Processing Information and Length, Weight, Sex, Age, Lipids, and Mercury Data for Fish Collected During the 2002 WSTMP.

Waterbody	Field ID (Ecy)	Species	Total Length (mm)	Fork Length (mm)	Weight (gm)	Collect Date	Process date	Fillet weight (gm)	Fillet taken (L, R, or B)	Skin status	Sex	Fish age (yrs)	% lipid	Hg (ug/kg ww)	MEL lab ID (03-)	Sample weight
American Lake	1	KOK	360	-	474	8/1/02	4/16/03	96	L	on	m	3	-	-	-	-
American Lake	2	KOK	379	-	569	8/1/02	4/16/03	120	L	on	m	3	-	-	-	-
American Lake	3	KOK	334	-	340	8/1/02	4/16/03	86	L	on	f	2	-	-	-	-
American Lake	4	KOK	346	-	413	8/1/02	4/16/03	99	L	on	m	3	-	-	-	-
American Lake	5	KOK	338	-	363	8/1/02	4/16/03	78	L	on	f	3	-	-	-	-
American Lake	6	KOK	342	-	384	8/1/02	4/16/03	87	L	on	f	3	-	-	-	-
American Lake	7	KOK	350	-	398	8/1/02	4/16/03	95	L	on	f	2	-	-	-	-
American Lake	8	KOK	314	-	267	8/1/02	4/16/03	75	L	on	f	3	-	-	-	-
American Lake	9	KOK	291	-	209	8/1/02	4/16/03	41	L	on	f	3	-	-	-	-
American Lake	**AMERKK**	**KOK**	**339.33**	-	**379.7**	8/1/02	4/16/03	**-**	**-**	**-**	**-**	**2.8**	**-**	**-**	**187203**	**40g/fish**
Conners Lake	7	RBT	338	-	377	8/5/02	4/18/03	-	-	on	m	-	-	-	-	-
Conners Lake	16	RBT	312	-	337	8/5/02	4/18/03	-	-	on	m	-	-	-	-	-
Conners Lake	17	RBT	353	-	476	8/5/02	4/18/03	-	-	on	f	-	-	-	-	-
Conners Lake	18	RBT	330	-	359	8/5/02	4/18/03	-	-	on	m	-	-	-	-	-
Conners Lake	20	RBT	314	-	327	8/5/02	4/18/03	-	-	on	f	-	-	-	-	-
Conners Lake	22	RBT	410	-	781	8/5/02	4/18/03	-	-	on	m	-	-	-	-	-
Conners Lake	23	RBT	361	-	554	8/5/02	4/18/03	-	-	on	m	-	-	-	-	-
Conners Lake	24	RBT	376	-	597	8/5/02	4/18/03	-	-	on	m	-	-	-	-	-
Conners Lake	28	RBT	386	-	676	8/5/02	4/18/03	-	-	on	f	-	-	-	-	-
Conners Lake	30	RBT	382	-	657	8/5/02	4/18/03	-	-	on	f	-	-	-	-	-
Conners Lake	**CONRT**	**RBT**	**356.2**	-	**514.1**	8/5/02	4/18/03	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**187210**	**40g/fish**
Deep Lake	1	CTT	263	-	142	8/7/02	4/15/03	-	B	on	m?	2	-	-	-	-
Deep Lake	2	CTT	281	-	191	8/7/02	4/15/03	-	B	on	m?	2	-	-	-	-
Deep Lake	3	CTT	256	-	133	8/7/02	4/15/03	-	B	on	m?	2	-	-	-	-
Deep Lake	4	CTT	265	-	153	8/7/02	4/15/03	-	B	on	f	2	-	-	-	-
Deep Lake	5	CTT	266	-	145	8/7/02	4/15/03	-	B	on	m?	3	-	-	-	-
Deep Lake	6	CTT	260	-	156	8/7/02	4/15/03	-	B	on	m?	2	-	-	-	-
Deep Lake	7	CTT	255	-	121	8/7/02	4/15/03	-	B	on	f	2	-	-	-	-
Deep Lake	8	CTT	250	-	128	8/7/02	4/15/03	-	B	on	f	2	-	-	-	-
Deep Lake	9	CTT	266	-	159	8/7/02	4/15/03	-	B	on	m?	2	-	-	-	-
Deep Lake	10	CTT	265	-	144	8/7/02	4/15/03	-	B	on	m?	2	-	-	-	-
Deep Lake	**DEEPCT**	**CTT**	**262.7**	-	**147.2**	8/7/02	4/15/03	**-**	**-**	**-**	**-**	**2.1**	**-**	**-**	**187202**	**50g/fish**
Kitsap Lake	1	CTT	271	258	205	10/31/02	4/15/03	-	L	on	m?	3	-	-	-	-
Kitsap Lake	2	CTT	255	243	191	10/31/02	4/15/03	-	L	on	m	2	-	-	-	-
Kitsap Lake	3	CTT	280	268	238	10/31/02	4/15/03	-	L	on	m?	2	-	-	-	-
Kitsap Lake	4	CTT	274	262	220	10/31/02	4/15/03	-	L	on	m?	3	-	-	-	-
Kitsap Lake	5	CTT	267	255	197	10/31/02	4/15/03	-	L	on	m	2	-	-	-	-
Kitsap Lake	6	CTT	258	248	181	10/31/02	4/15/03	-	L	on	m	2	-	-	-	-
Kitsap Lake	7	CTT	298	286	308	10/31/02	4/15/03	-	L	on	f	3	-	-	-	-
Kitsap Lake	**KITCT**	**CTT**	**271.86**	-	**220.0**	10/31/02	4/15/03	**-**	**-**	**-**	**-**	**2.4**	**-**	**-**	**187201**	**50g/fish**
Kitsap Lake	Kitsap01	LMB	431	420	1563	10/31/02	11/12/02	258	L	off	m	7	0.93	511	-	-
Kitsap Lake	Kitsap02	LMB	362	350	371	10/31/02	11/12/02	152	L	off	m	3	0.81	342	-	-
Kitsap Lake	Kitsap03	LMB	376	365	1004	10/31/02	11/12/02	163	L	off	m	3	1.71	242	-	-
Kitsap Lake	Kitsap04	LMB	380	372	1123	10/31/02	11/12/02	183	L	off	f	3	2.38	264	-	-
Kitsap Lake	Kitsap05	LMB	355	343	780	10/31/02	11/12/02	82	L	off	f	3	1.18	147	-	-
Kitsap Lake	Kitsap06	LMB	410	398	1236	10/31/02	11/12/02	130	L	off	f	3	0.48	366	-	-
Kitsap Lake	Kitsap07	LMB	355	345	857	10/31/02	11/12/02	136	R	off	m	3	0.44	164	-	-
Kitsap Lake	Kitsap08	LMB	321	310	547	10/31/02	11/12/02	95	L	off	f	2	0.43	155	-	-
Kitsap Lake	Kitsap09	LMB	310	300	473	10/31/02	11/12/02	143	B	off	m	2	0.66	185	-	-
Kitsap Lake	Kitsap10	LMB	495	466	2716	10/31/02	11/12/02	323	L	off	m	12	0.57	754	-	-
Kitsap Lake	**KITLMB**	**LMB**	**380**	-	**1067.0**	10/31/02	11/12/02	**-**	**-**	**-**	**-**	**4.1**	**0.96**	**313**	**187200**	**20g/fish**
Kitsap Lake	1	RBT	297	280	274	10/31/02	4/16/03	60	L	on	u	1	-	-	-	-
Kitsap Lake	2	RBT	225	212	124	10/31/02	4/16/03	30	B	on	m	1	-	-	-	-
Kitsap Lake	3	RBT	435	410	882	10/31/02	4/16/03	191	L	on	u	2	-	-	-	-
Kitsap Lake	4	RBT	340	322	421	10/31/02	4/16/03	92	L	on	m	2	-	-	-	-
Kitsap Lake	5	RBT	330	315	433	10/31/02	4/16/03	98	L	on	m	-	-	-	-	-
Kitsap Lake	**KITRT**	**RBT**	**325.4**	-	**426.8**	10/31/02	4/16/03	**-**	**-**	**-**	**-**	**1.5**	**-**	**-**	**187204**	**55g/fish**
Long Lake (upper)	14 d	MWF	287	-	230	6/18/01	4/22/02	42	-	on	f	3	-	-	-	-
Long Lake (upper)	27d	MWF	291	-	188	6/19/01	4/22/02	35	-	on	f	4	-	-	-	-
Long Lake (upper)	28d	MWF	306	-	247	6/19/01	4/22/02	53	-	on	m	4	-	-	-	-
Long Lake (upper)	35d	MWF	281	-	212	6/19/01	4/22/02	45	-	on	f	4	-	-	-	-
Long Lake (upper)	42 d	MWF	295	-	206	6/19/01	4/22/02	43	-	on	f	3	-	-	-	-
Long Lake (upper)	53 d	MWF	300	-	231	6/20/01	4/22/02	54	-	on	f	4	-	-	-	-
Long Lake (upper)	54 d	MWF	298	-	236	6/20/01	4/22/02	55	-	on	m	5	-	-	-	-
Long Lake (upper)	55 d	MWF	277	-	174	6/20/01	4/22/02	42	-	on	m	3	-	-	-	-
Long Lake (upper)	56d	MWF	265	-	164	6/20/01	4/22/02	36	-	on	m	3	-	-	-	-
Long Lake (upper)	57d	MWF	272	-	165	6/20/01	4/22/02	36	-	on	f	3	-	-	-	-
Long Lake (upper)	**LL10-F-C**	**MWF**	**287.2**	**-**	**205.3**	6/20/01	4/22/02	**-**	**-**	**-**	**-**	**3.6**	**-**	**-**	**187212**	**32g/fish**

Table D-1 (cont). Field Processing Information and Length, Weight, Sex, Age, Lipids, and Mercury Data for Fish Collected During the 2002 WSTMP.

Waterbody	Field ID (Ecy)	Species	Total Length (mm)	Fork Length (mm)	Weight (gm)	Collect Date	Process date	Fillet weight (gm)	Fillet taken (L, R, or B)	Skin status	Sex	Fish age (yrs)	% lipid	Hg (ug/kg ww)	MEL lab ID (03-)	Sample weight
Moses Lake	Moses01	LMB	500	490	2413	10/22/02	10/30/02	346	L	off	f	5	1.12	90	-	-
Moses Lake	Moses02	LMB	465	455	2080	10/22/02	10/30/02	303	L	off	f	5	1.77	105	-	-
Moses Lake	Moses03	LMB	420	411	1362	10/22/02	10/30/02	207	L	off	f	3	0.84	50	-	-
Moses Lake	Moses04	LMB	355	340	738	10/22/02	10/30/02	111	L	off	m	2	0.77	33	-	-
Moses Lake	Moses05	LMB	395	383	1232	10/22/02	10/30/02	190	L	off	m	4	1.27	61	-	-
Moses Lake	Moses06	LMB	322	315	699	10/22/02	10/30/02	100	L	off	m	2	0.73	26	-	-
Moses Lake	Moses07	LMB	570	555	3636	10/22/02	10/30/02	515	L	off	f	11	1.01	181	-	-
Moses Lake	Moses08	LMB	505	490	2585	10/22/02	10/30/02	344	L	off	-	15	0.92	142	-	-
Moses Lake	Moses09	LMB	495	480	2655	10/22/02	10/30/02	338	L	off	f	6	0.98	92	-	-
Moses Lake	Moses10	LMB	440	430	1660	10/22/02	10/30/02	212	L	off	m	5	0.45	79	-	-
Moses Lake	**MOSLMB**	**LMB**	**447**	-	**1906.0**	10/22/02	10/30/02	**-**	**-**	**-**	**-**	**5.8**	**0.99**	**86**	**187206**	**30g/fish**
Moses Lake	1	RBT	480	-	1081	10/22/02	4/17/03	288	L	on	f	2	-	-	-	-
Moses Lake	2	RBT	475	-	1254	10/22/02	4/17/03	311	L	on	m	2	-	-	-	-
Moses Lake	3	RBT	470	-	1184	10/23/02	4/17/03	294	L	on	m	2	-	-	-	-
Moses Lake	4	RBT	500	-	1582	10/23/02	4/17/03	364	L	on	f	3	-	-	-	-
Moses Lake	5	RBT	520	-	1666	10/23/02	4/17/03	379	L	on	m	3	-	-	-	-
Moses Lake	7	RBT	490	-	1376	10/23/02	4/17/03	347	L	on	f	2	-	-	-	-
Moses Lake	**MOSRT**	**RBT**	**489.17**	-	**1357.17**	10/23/02	4/17/03	**-**	**-**	**-**	**-**	**2.3**	**-**	**-**	**187208**	**260g/fish**
Moses Lake	1	WAL	445	-	900	10/22/02	4/18/03	184	L	on	m	2	-	-	-	-
Moses Lake	2	WAL	445	-	1009	10/22/02	4/18/03	191	L	on	m	2	-	-	-	-
Moses Lake	3	WAL	430	-	814	10/22/02	4/18/03	160	L	on	m	2	-	-	-	-
Moses Lake	4	WAL	415	-	737	10/22/02	4/18/03	143	L	on	m	1	-	-	-	-
Moses Lake	5	WAL	430	-	856	10/22/02	4/18/03	170	L	on	m	2	-	-	-	-
Moses Lake	6	WAL	415	-	740	10/22/02	4/18/03	154	L	on	m	2	-	-	-	-
Moses Lake	7	WAL	425	-	772	10/22/02	4/18/03	161	L	on	f	2	-	-	-	-
Moses Lake	8	WAL	515	-	1567	10/23/02	4/18/03	341	L	on	m	3	-	-	-	-
Moses Lake	9	WAL	465	-	1082	10/23/02	4/18/03	241	L	on	m	2	-	-	-	-
Moses Lake	**MOSWAL**	**WAL**	**442.78**	-	**941.9**	10/23/02	4/18/03	**-**	**-**	**-**	**-**	**2.0**	**-**	**-**	**187211**	**100g/fish**
Vancouver Lake	Vancouv 01	LMB	269	265	360	10/3/02	10/4/02	46	L	off	m	1	0.41	55	-	-
Vancouver Lake	Vancouv 02	LMB	282	270	371	10/3/02	10/4/02	51	B	off	m	1	0.50	61	-	-
Vancouver Lake	Vancouv 03	LMB	260	252	300	10/3/02	10/4/02	53	B	off	f	1	0.47	47	-	-
Vancouver Lake	Vancouv 04	LMB	270	265	338	10/3/02	10/4/02	67	B	off	m	1	0.62	62	-	-
Vancouver Lake	Vancouv 05	LMB	285	280	412	10/3/02	10/4/02	67	B	off	m	1	0.40	88	-	-
Vancouver Lake	Vancouv 06	LMB	290	280	423	10/3/02	10/4/02	62	B	off	f	2	0.64	91	-	-
Vancouver Lake	Vancouv 07	LMB	260	253	324	10/3/02	10/4/02	55	B	off	m	1	0.38	89	-	-
Vancouver Lake	Vancouv 08	LMB	265	260	310	10/3/02	10/4/02	52	B	off	m	1	0.55	91	-	-
Vancouver Lake	Vancouv 09	LMB	470	455	2013	10/3/02	10/4/02	128	L	off	m	7	0.59	476	-	-
Vancouver Lake	Vancouv 10	LMB	405	390	1405	10/3/02	10/4/02	101	L	off	m	7	0.35	540	-	-
Vancouver Lake	**VNCLMB**	**LMB**	**306**	-	**625.6**	10/3/02	10/4/02	**-**	**-**	**-**	**-**	**2.3**	**0.49**	**160**	**187207**	**20g/fish**
West Medical Lake	1	RBT	350	-	488	10/23/02	4/16/02	123	R	on	u	1	-	-	-	-
West Medical Lake	2	RBT	365	-	453	10/23/02	4/16/02	92	L	on	u	1	-	-	-	-
West Medical Lake	3	RBT	445	-	871	10/23/02	4/16/02	200	L	on	m?	1	-	-	-	-
West Medical Lake	4	RBT	435	-	839	10/23/02	4/16/02	208	R	on	f?	1	-	-	-	-
West Medical Lake	5	RBT	413	-	752	10/23/02	4/16/02	154	R	on	f	2	-	-	-	-
West Medical Lake	6	RBT	432	-	952	10/23/02	4/16/02	200	R	on	f	2	-	-	-	-
West Medical Lake	7	RBT	410	-	650	10/23/02	4/16/02	147	L	on	f	1	-	-	-	-
West Medical Lake	8	RBT	377	-	516	10/23/02	4/16/02	130	L	on	m	1	-	-	-	-
West Medical Lake	9	RBT	380	-	550	10/23/02	4/16/02	135	L	on	m	1	-	-	-	-
West Medical Lake	10	RBT	364	-	531	10/23/02	4/16/02	142	L	on	f	1	-	-	-	-
West Medical Lake	**WMEDRT**	**RBT**	**397.1**	-	**660.2**	10/23/02	4/16/02	**-**	**-**	**-**	**-**	**1.2**	**-**	**-**	**187205**	**90g/fish**

Bold - Field ID samples are composite samples of the preceding fish of the same species.

Data for composite samples is the average value of individual fish that make up the composite.

Species codes:

CTT	Cutthroat trout (*Oncorhynchus clarki*)
KOK	Kokanee (*Oncorhynchus nerka*)
LMB	Largemouth bass (*Micropterus salmoides*)
MWF	Mountain whitefish (*Prosopium williamsoni*)
RBT	Rainbow trout (*Oncorhynchus mykiss*)
WAL	Walleye (*Stizostedion vitreum*)

Table D-2. Fish Tissue Results for Mercury, PCBs, PCDD/Fs, Pesticides, and PBDEs with Comparison to Criteria for Protection of Human Health, WSTMP 2002.

Site -->	Vancouver		Kitsap		Kitsap		Kitsap		American		Moses		Moses		Moses		Deep		Conners		West Medical		Long Lake [6]	National Toxics Rule	EPA SVs: Subsistence Fishers		EPA SVs: Recreational Fishers	
Species -->	LMB		LMB		CTT		RBT		KOK		LMB		WAL		RBT		CTT		RBT		RBT		MWF		Non-carcinogenic	Carcinogenic	Non-carcinogenic	Carcinogenic
Analyte [1]																												
Mercury [4]	***160***		***313***		**91**		**96**		**90**		***86***		35		25		15		41		**60**		na	825, 300 [5]	49		400	
PCB-1248									3.2	NJ																		
PCB-1254	6.0		4.7	J	6.8	NJ	4.9	J	13		14	NJ	3.7	J	9.0						25							
PCB-1260					4.7	NJ	4.7	NJ	4.3	J	3.9	NJ			2.8	NJ					11	J						
Total PCBs	**6.0**		**4.7**		**11.5**		**9.6**		**20.5**		**17.9**		**3.7**		**11.8**		2.3	U	2.3	U	**36**			5.3	9.83	2.45	80	20
PCDD/Fs [3]	na		na		**0.0702** [a]		ND		**0.1917**		na		ND		**0.1200**		na		ND		**0.0840**		**0.0860**	0.07		0.0315		0.256
2,4'-DDE															1.8													
4,4'-DDD	0.44	J							1.8		3.4		0.53	J	5.9						1.2			45				
4,4'-DDE	2.7		1.4		1.5	J	2.2		4.7		13		3.9		23		1.4		1.1		9.5			31.6				
4,4'-DDT									0.75	J														31.6				
Total DDTs	3.14		1.4		1.5		2.2		7.25		**16.4**		4.43		**30.7**		1.4		1.1		10.7				245	14.4	2000	117
Cis-Chlordane									0.81	J																		
Trans-Nonachlor			0.6				0.46	J	1.5						0.54													
Total Chlordanes			0.6				0.46		2.31						0.54									8.3	245	14.0	2000	114
DDMU [2]											1.6	J																
Dieldrin									**1.2**															0.65	24	0.307	200	2.5
Hexachlorobenzene									2.2	J					0.41	J								6.7	393	3.07	3200	25.0
Pentachloroanisole									1.1	NJ									0.41	J								
Methoxychlor					1.2	NJ																						
PBDE-47 (2,2',4,4'-tetraBDE)	1.2		1.8				1.2		2.3												4.3							
PBDE-99 (2,2',4,4',5-pentaBDE)									1.1	J											0.84	J						
PBDE-100 (2,2',4,4',6-pentaBDE)																					1.7	J						
Total PBDEs	1.2		1.8				1.2		3.4												6.84							
Percent Lipids (MEL)	0.44		0.99		1.79		1.76		8.13		1.45		1.24		4.39		1.33		3.31		2.36		1.72					
MEL Sample ID (03-)	187207		187200		187201		187204		187203		187206		187211		187208		187202		187210		187205		187212					

Shaded value: exceeds National Toxics Rule criterion

Bold value: exceeds EPA 2000 SVs

J: The analyte was positively identified. The associated numerical value is an estimate.

NJ: There is evidence that the analyte is present. The associated numerical result is an estimate.

ND: Not detected

na: not analyzed

a: Result is for the lab duplicate sample; the original sample result was ND

1 - Values in parts per billion wet weight (ug/kg ww) unless otherwise noted.

2 - DDMU is a breakdown product of DDE: 1-Chloro-2,2-bis(4'-chlorophenyl)ethylene.

3 - PCDD/Fs as 2,3,7,8-TCDD TEQ; values are in parts per trillion wet weight (ng/kg ww).

4 - Italicized mercury results from Fischnaller et al., 2003; and are the mean value of 10 individual fish.

5 - EPA (2001) proposed 300 ppb ww as the criterion for mercury.

6 - Long Lake sample analyzed only for dioxin/furans.

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Table D-3. Results for PCDD/F Congeners from Composite Fish Tissue Samples, WSTMP 2002.

Site & species:		Kitsap CTT				Kitsap CTT (lab dup)				American KOK				Kitsap RBT				West Medical RBT			
MEL Sample ID:		187201				187201 (lab dup)				187203				187204				187205			
% Lipids:		1.92				-				8.47				2.17				2.37			
Analyte	TEF	RR		TEQ (ND= zero)	TEQ (ND = 1/2 RL	RR		TEQ (ND= zero)	TEQ (ND = 1/2 RL	RR		TEQ (ND= zero)	TEQ (ND = 1/2 RL	RR		TEQ (ND= zero)	TEQ (ND = 1/2 RL	RR		TEQ (ND= zero)	TEQ (ND = 1/2 RL
1,2,3,4,6,7,8,9-OCDD	0.0001	1.20	UJ	0	0.00006	1.60	NJ	0.0002	0.0002	1.30	UJ	0	7E-05	0.81	UJ	0	4E-05	0.57	UJ	0	2.9E-05
1,2,3,4,6,7,8,9-OCDF	0.0001	0.97	UJ	0	4.9E-05	0.61	UJ	0	3E-05	0.88	UJ	0	4E-05	0.39	UJ	0	2E-05	0.59	UJ	0	3E-05
1,2,3,4,6,7,8-HpCDD	0.01	1.50	UJ	0	0.0075	0.69	UJ	0	0.0035	0.77	J	0.0077	0.0077	0.57	UJ	0	0.0029	0.53	UJ	0	0.00265
1,2,3,4,6,7,8-HpCDF	0.01	0.41	UJ	0	0.00205	0.62	UJ	0	0.0031	0.47	UJ	0	0.0024	0.22	UJ	0	0.0011	0.34	UJ	0	0.0017
1,2,3,4,7,8,9-HpCDF	0.01	0.60	UJ	0	0.003	0.81	UJ	0	0.0041	0.62	UJ	0	0.0031	0.45	UJ	0	0.0023	0.25	UJ	0	0.00125
1,2,3,4,7,8-HxCDD	0.1	0.78	UJ	0	0.039	0.54	UJ	0	0.027	0.55	UJ	0	0.0275	0.49	UJ	0	0.0245	0.61	UJ	0	0.0305
1,2,3,4,7,8-HxCDF	0.1	0.36	UJ	0	0.018	0.51	UJ	0	0.0255	0.65	UJ	0	0.0325	0.55	UJ	0	0.0275	0.73	UJ	0	0.0365
1,2,3,6,7,8-HxCDD	0.1	0.80	UJ	0	0.04	0.70	UJ	0	0.035	0.64	NJ	0.064	0.064	0.56	UJ	0	0.028	0.49	UJ	0	0.0245
1,2,3,6,7,8-HxCDF	0.1	0.35	UJ	0	0.0175	0.95	UJ	0	0.0475	0.29	UJ	0	0.0145	0.50	UJ	0	0.025	0.42	UJ	0	0.021
1,2,3,7,8,9-HxCDD	0.1	0.74	UJ	0	0.037	0.43	UJ	0	0.0215	0.44	UJ	0	0.022	0.43	UJ	0	0.0215	0.60	UJ	0	0.03
1,2,3,7,8,9-HxCDF	0.1	0.50	UJ	0	0.025	0.57	UJ	0	0.0285	0.55	UJ	0	0.0275	0.45	UJ	0	0.0225	0.29	UJ	0	0.0145
1,2,3,7,8-PeCDD	1	0.97	UJ	0	0.485	0.89	UJ	0	0.445	0.55	UJ	0	0.275	0.59	UJ	0	0.295	0.52	UJ	0	0.26
1,2,3,7,8-PeCDF	0.05	0.85	UJ	0	0.02125	0.76	UJ	0	0.019	0.61	UJ	0	0.0153	0.58	UJ	0	0.0145	0.45	UJ	0	0.01125
2,3,4,6,7,8-HxCDF	0.1	0.37	UJ	0	0.0185	0.52	UJ	0	0.026	0.29	UJ	0	0.0145	0.51	UJ	0	0.0255	0.50	UJ	0	0.025
2,3,4,7,8-PeCDF	0.5	0.60	UJ	0	0.15	0.49	UJ	0	0.1225	0.38	UJ	0	0.095	0.30	UJ	0	0.075	0.38	UJ	0	0.095
2,3,7,8-TCDD	1	0.78	UJ	0	0.39	0.68	UJ	0	0.34	0.72	UJ	0	0.36	0.69	UJ	0	0.345	0.52	UJ	0	0.26
2,3,7,8-TCDF	0.1	0.54	UJ	0	0.027	0.70	J	0.07	0.07	1.20		0.12	0.12	0.61	UJ	0	0.0305	0.84	J	0.084	0.084
TEQ 2,3,7,8 TCDD				**0.0000**	**1.2809**			**0.0702**	**1.2183**			**0.1917**	**1.0810**			**0.0000**	**0.9408**			**0.0840**	**0.8979**
Exceedance factors for:																					
NTR (0.07 ppt ww)	0.07			0.0	18.3			1.0	17.4			2.7	15.4			0.0	13.4			1.2	12.8
EPA SV Subsistence (0.0315 ppt ww)	0.0315			0.0	40.7			2.2	38.7			6.1	34.3			0.0	29.9			2.7	28.5
EPA SV Recreational (0.256 ppt ww)	0.256			0.0	5.0			0.3	4.8			0.7	4.2			0.0	3.7			0.3	3.5

TEF - Toxicity Equivalence Factor from Van den Berg et al., 1998

RR - Reported Result in ppt ww

RL - Reporting Limit in ppt ww

ppt ww - Parts per trillion, wet weight

U - The analyte was not detected at or above the reported value.

J - The analyte was positively identified. The associated numerical value is an estimate.

UJ - The analyte was not detected at or above the reported estimated result.

NJ - There is evidence that the analyte is present. The associated numerical result is an estimate.

Table D-3 (cont.). Results for PCDD/F Congeners from Composite Fish Tissue Samples, WSTMP 2002.

Site & species:		Moses RBT				Moses RBT (field dup)				Conners RBT				Moses WAL				Long Lake MWF			
MEL Sample ID:		187208				187209				187210				187211				187212			
% Lipids:		4.47				2.69				3.06				1.25				1.72			
Analyte	TEF	RR		TEQ (ND= zero)	TEQ (ND = 1/2 RL	RR		TEQ (ND= zero)	TEQ (ND = 1/2 RL	RR		TEQ (ND= zero)	TEQ (ND @ 1/2 RL	RR		TEQ (ND= zero)	TEQ (ND @ 1/2 RL	RR		TEQ (ND= zero)	TEQ (ND @ 1/2 RL
1,2,3,4,6,7,8,9-OCDD	0.0001	0.82	UJ	0	4E-05	0.94	UJ	0	4.7E-05	0.76	UJ	0	4E-05	1.10	UJ	0	6E-05	0.94	UJ	0	4.7E-05
1,2,3,4,6,7,8,9-OCDF	0.0001	0.73	UJ	0	4E-05	0.57	UJ	0	2.9E-05	0.90	UJ	0	5E-05	0.82	UJ	0	4E-05	0.57	UJ	0	2.9E-05
1,2,3,4,6,7,8-HpCDD	0.01	0.67	UJ	0	0.0034	0.73	UJ	0	0.00365	0.92	UJ	0	0.0046	0.88	UJ	0	0.0044	0.82	UJ	0	0.0041
1,2,3,4,6,7,8-HpCDF	0.01	0.31	UJ	0	0.0016	0.48	UJ	0	0.0024	0.67	UJ	0	0.0034	0.58	UJ	0	0.0029	1.40	UJ	0	0.007
1,2,3,4,7,8,9-HpCDF	0.01	0.36	UJ	0	0.0018	0.44	UJ	0	0.0022	0.32	UJ	0	0.0016	0.46	UJ	0	0.0023	1.00	UJ	0	0.005
1,2,3,4,7,8-HxCDD	0.1	0.63	UJ	0	0.0315	0.47	UJ	0	0.0235	0.55	UJ	0	0.0275	0.39	UJ	0	0.0195	0.58	UJ	0	0.029
1,2,3,4,7,8-HxCDF	0.1	0.33	UJ	0	0.0165	0.45	UJ	0	0.0225	0.59	UJ	0	0.0295	0.37	UJ	0	0.0185	0.61	UJ	0	0.0305
1,2,3,6,7,8-HxCDD	0.1	0.59	UJ	0	0.0295	0.66	UJ	0	0.033	0.55	UJ	0	0.0275	0.47	UJ	0	0.0235	0.69	UJ	0	0.03465
1,2,3,6,7,8-HxCDF	0.1	0.31	UJ	0	0.0155	0.39	UJ	0	0.0195	0.55	UJ	0	0.0275	0.39	UJ	0	0.0195	0.45	UJ	0	0.0225
1,2,3,7,8,9-HxCDD	0.1	0.42	UJ	0	0.021	0.58	UJ	0	0.029	0.54	UJ	0	0.027	0.56	UJ	0	0.028	0.60	UJ	0	0.03
1,2,3,7,8,9-HxCDF	0.1	0.43	UJ	0	0.0215	0.42	UJ	0	0.021	0.58	UJ	0	0.029	0.40	UJ	0	0.02	0.34	UJ	0	0.017
1,2,3,7,8-PeCDD	1	0.47	UJ	0	0.235	0.62	UJ	0	0.31	0.48	UJ	0	0.24	0.65	UJ	0	0.325	0.92	UJ	0	0.46
1,2,3,7,8-PeCDF	0.05	0.48	UJ	0	0.012	0.41	UJ	0	0.01025	0.85	UJ	0	0.0213	0.66	UJ	0	0.0165	0.81	UJ	0	0.02025
2,3,4,6,7,8-HxCDF	0.1	0.33	UJ	0	0.0165	0.41	UJ	0	0.0205	0.51	UJ	0	0.0255	0.44	UJ	0	0.022	0.40	UJ	0	0.02
2,3,4,7,8-PeCDF	0.5	0.44	UJ	0	0.11	0.53	UJ	0	0.1325	0.28	UJ	0	0.07	0.36	UJ	0	0.09	0.42	UJ	0	0.105
2,3,7,8-TCDD	1	0.68	UJ	0	0.34	0.49	UJ	0	0.245	0.67	UJ	0	0.335	0.82	UJ	0	0.41	0.96	UJ	0	0.48
2,3,7,8-TCDF	0.1	1.20		0.12	0.12	1.00		0.1	0.1	0.34	UJ	0	0.017	0.35	UJ	0	0.0175	0.86	NJ	0.086	0.086
TEQ 2,3,7,8 TCDD				**0.1200**	**0.9758**			**0.1000**	**0.9751**			**0.0000**	**0.8864**			**0.0000**	**1.0197**			**0.0860**	**1.3511**
Exceedance factors for:																					
NTR (0.07 ppt ww)	0.07			1.7	13.9			1.4	13.9			0.0	12.7			0.0	14.6			1.2	19.3
EPA SV Subsistence (0.0315 ppt ww)	0.0315			3.8	31.0			3.2	31.0			0.0	28.1			0.0	32.4			2.7	42.9
EPA SV Recreational (0.256 ppt ww)	0.256			0.5	3.8			0.4	3.8			0.0	3.5			0.0	4.0			0.3	5.3

TEF - Toxicity Equivalence Factor from Van den Berg et al., 1998
RR - Reported Result in ppt ww
RL - Reporting Limit in ppt ww
ppt ww - Parts per trillion, wet weight
U - The analyte was not detected at or above the reported value.
J - The analyte was positively identified. The associated numerical value is an estimate.
UJ - The analyte was not detected at or above the reported estimated result.
NJ - There is evidence that the analyte is present. The associated numerical result is an estimate.

Appendix E

Water Sample Data

Table E-1. Results for Conventional Water Quality Parameters, WSTMP 2002.

Site	Date	Time	pH (S.U.)	Temp (deg C)	Cond (umho/cm)	Flow (cfs)	TSS (mg/L)	TOC (mg/L)	MEL Lab ID (03-)
102nd St. Drain	5/22/02	2120	7.0	15.9	205	2.1	6	15.7	218058
	6/19/02	1525	7.2	14.7	235	0.66	6	11.9	258058
	8/21/02	1130	6.4	13.4	225	0.18	1 U	8.4	348048
Fry Creek	5/22/02	1835	7.5	13.1	222	3.0	4	2.3	218057
	6/19/02	1245	7.3	14.4	310	1.9	8	3.5	258057
	8/21/02	845	6.7	14.9	3170*	1.4	16	4.1	348047
Latah Creek [1]	5/20/02	1500	8.8	15.8	212	80.7	3	4.2	218050
	6/17/02	1500	8.0	21.8	180	13.3	8	4.5	258050
	8/19/02	1550	8.8	22.0	255	0.8	3	4.8	348040
Little Deep Creek	5/20/02	1630	8.0	12.5	106	10.7	9	2.6	218051
	6/17/02	1250	7.6	14.5	167	3.9	5	3.0	258051
	8/19/02	1350	8.5	12.7	430	0.6	1 U	1.3	348041
Matriotti Creek	5/22/02	1430	7.7	11.2	190	15.5	2	2.0	218056
	6/19/02	900	7.6	10.3	167	15.4	3	1.5	258056
	8/21/02	1655	7.5	14.0	230	12.5	2	2.0	348046
Mercer Creek	5/22/02	940	7.6	11.7	196	10.7	5	4.5	218055
	6/18/02	1555	7.7	14.0	240	15.4	13	4.4	258055
	8/20/02	1455	7.1	15.2	210	5.9	1	5.4	348045
Peshastin Creek	5/21/02	640	-	5.5	95	-	16	2.0	218052
	6/17/02	2015	7.4	10.5	70	-	7	2.9	258052
	8/19/02	2015	8.0	17.5	130	-	1 U	1.0 U	348042
Tenmile Creek	5/21/02	1330	7.7	11.7	285	20 E	3	6.6	218053
	6/18/02	1210	7.1	13.3	330	9.7	2	5.6	258053
	8/20/02	1145	7.1	13.8	400	3.6	2	4.5	348043

* Analyzed at MEL

1- Latah Creek @ Hatch Rd sampled on 5/22/02, Latah Creek near Waverly sampled on 6/17/02 and 8/19/02

U = the analyte was not detected at or above the reported result

E = estimated value

Table E-2. Results for Pesticides Detected in Water Samples, WSTMP 2002.

		Latah	Latah-Wav		Little Deep			Peshastin			Tenmile			Mercer			Matriotti			Fry			102nd St.		
Type	Analyte	5/20	6/17	8/19	5/20	6/17	8/19	5/21	6/17	8/19	5/21	6/18	8/19	5/22	6/18	8/20	5/22	6/19	8/21	5/22	6/19	8/21	5/22	6/19	8/21
N, B	2,6-dichlorobenzamide														0.20 J					0.096 J				0.20 J	0.17 J
N, F	Chlorothalonil (Daconil)					none												none						0.0027 J	
N, H	Atrazine					detected						0.0042 J						detected							
N, H	Benefin					at												at						0.0063 J	
N, H	Bromacil	0.013 J	0.047 J	0.029 J		any												any							
N, H	Dichlobenil		0.027 J			time								0.037 J	0.013 J			time						0.089 J	
N, H	Diuron	0.049 NJ						0.038 NJ						0.045 NJ	0.030 J					0.15 NJ					
N, H	Ethalfluralin (Sonalan)	0.033 J																							
N, H	Fluridone		0.22 J																						
N, H	Napropamide																							0.0090 J	
N, H	Norflurazon																							0.013 J	
N, H	Pronamide (Kerb)																							0.0063 J	
N, H	Triallate		0.17																						
OC, I	Trans-Nonachlor	0.0016 J																							
OP, I	Dialifor	0.12 J						0.019 J																	
OP, I	Diazinon											**0.0055 J**		**0.040 J**	**0.050 J**	**0.026 J**								**0.0057 J**	
OP, I	Tetrachlorvinphos	0.0042 J																							
D	Acetaminophen													0.058 J											
D	Caffeine	0.019 J												0.017 J											

N - Nitrogen
OP - Organophosphorus
OC - Organochlorine
D - Drug
H - Herbicide
F - Fungicide
I - Insecticide
B - Breakdown product of herbicide dichlobenil

J - The analyte was positively identified. The associated numerical value is an estimate.
NJ - There is evidence that the analyte is present. The associated numerical result is an estimate.

Bold values exceed chronic criterion of 0.003 ug/L for the protection of aquatic life: developed in Quebec (MENVIQ, 1990).
Shaded values exceed chronic criterion of 0.04 ug/L for the protection of aquatic life: developed in California (Menconi and Cox, 1994).