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Wenatchee River
PCB and DDT
Source Assessment

by

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Water Resource Inventory Area (WRIA) and 8-digit Hydrologic Unit Code (HUC) numbers for the study area:

- WRIA - 45 (Wenatchee River basin)
- HUC number - 17020011

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Abstract

The Wenatchee River has had some of the highest fish tissue concentrations of polychlorinated biphenyls (PCBs) measured in Washington State within the last 10-15 years. As a result of both PCBs and dichloro-diphenyl-trichloroethane (DDT) contamination in resident fish, there are currently eight listings for water quality impairment under the federal Clean Water Act, Section 303(d). This report details the findings of a two-phase sampling program which assessed concentrations of PCBs and DDT in water, biota, and sediment throughout the Wenatchee River basin during 2014-2015.

Sampling results identified two chemically-distinct sources of PCBs to the Wenatchee River, one located near the City of Cashmere and the second near the City of Wenatchee. Concentrations of PCBs in biofilms on rocks (mainly attached algae) are highly correlated with dissolved PCB concentrations in the water. PCB concentrations in biofilms were higher in the low-flow period (August to October) compared to the high-flow period (May). High concentrations of PCBs in biofilms represent the entry into the Wenatchee food web. The location of the contaminated food source for Wenatchee resident fish is confined to the lower Wenatchee (downstream of Cashmere).

The main known sources of DDT to the Wenatchee River are within the Mission and Chumstick Creek sub-basins. The inputs of DDT to the Wenatchee River are greatest during high-flow periods of the year (April to June). Loading calculations for DDT in the Wenatchee River revealed a possible unknown source somewhere between river mile 21 (upstream of Peshastin) and 7 (upstream of Monitor).

The sources of PCBs and DDT are not related and will require different approaches for further investigation and remediation. Ecology recommends further source tracing for PCBs and DDT to refine locations and load estimates, collaboration with Washington Department of Agriculture to monitor DDT in the Mission and Chumstick Creek basins, and additional research to improve understanding of the Wenatchee River food web and bioaccumulation of toxics.

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Executive Summary

The Wenatchee River has had some of the highest fish tissue concentrations of polychlorinated biphenyls (PCBs) in Washington State within the last 10-15 years. As a result of both PCBs and dichloro-diphenyl-trichloroethane (DDT) contamination in resident fish tissues, there are currently 8 listings for water quality impairment under the federal Clean Water Act, Section 303(d). In addition, a consumption advisory has been placed on mountain whitefish from the lower Wenatchee River by the Washington Department of Health (DOH). Fish advisories are based on the same data, but not the same thresholds for impairment as the 303(d) list.

As part of the process to reduce the concentrations of PCBs and DDT found in resident fish tissues in the Wenatchee River, the Washington State Department of Ecology (Ecology) initiated a source assessment study to identify and prioritize sources of PCBs and DDT to the Wenatchee River. The specific objectives of the study were: (1) to conduct an initial synoptic survey to assess the spatial distribution of PCBs, DDT, and DDT analogues DDD and DDE in the mainstem of the Wenatchee River, and (2) to identify and characterize sources of these compounds to the Wenatchee River, based on the results of the synoptic survey.

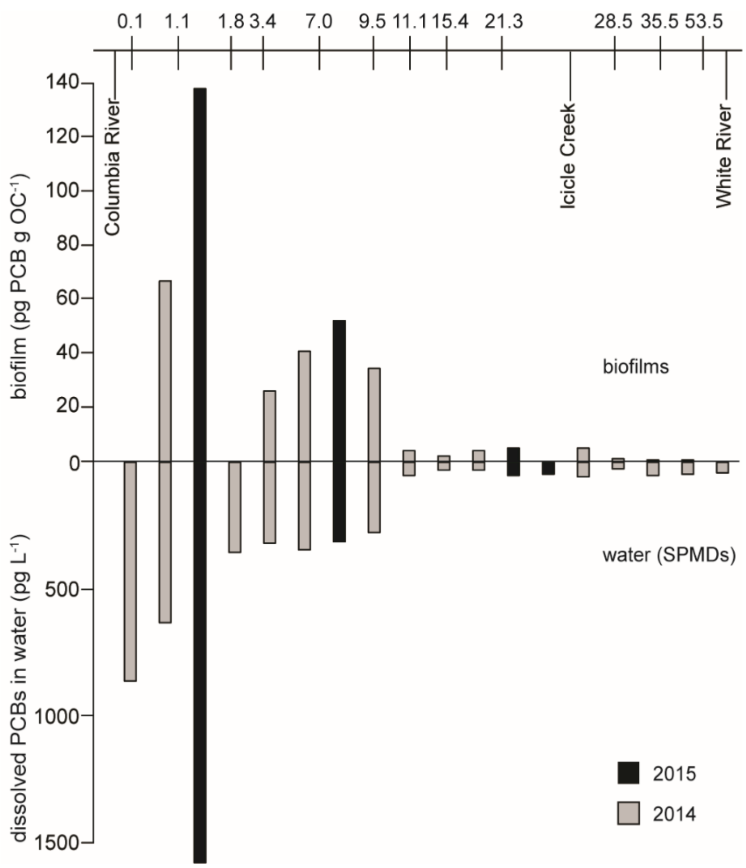


Figure ES-1: Barplot of PCBs in periphyton (upper) and water (lower) of the Wenatchee River during low-flow (September) over 2014 and 2015.

River mile for the Wenatchee at the top of the figure.

Findings

This study assessed the concentrations of PCBs and DDT in water, biofilms (algae and microbial biomass), and invertebrates in the Wenatchee River basin during 2014 and 2015. The initial survey showed that the sources of both contaminants are confined to the lower Wenatchee River. The sources of PCBs and DDT are not related and will require different approaches for further investigation and remediation.

There are two chemically distinct sources of PCBs to the Wenatchee River. One is located near the City of Cashmere and the second near the City of Wenatchee. This study confined the City of Cashmere site to approximately 2 river miles and the City of Wenatchee site to approximately 0.7 river miles (Figure ES-1). PCB concentrations in biofilms were higher during the low-flow period (August to October) and the spatial trend of PCB concentrations does not appear to change between high- and low-flow. Therefore, it is likely that the main PCB sources are not dominated by stormwater and could be unknown contaminated sites contributing PCB-contaminated groundwater.

This study has eliminated a number of potential PCB sources that have either been previously investigated or speculated upon, including: the Leavenworth National Fish Hatchery, historic rail activities in Leavenworth, the former Great Northern Railway powerhouse upstream of Leavenworth in Tumwater Canyon, and the former dump site in Dryden. Furthermore, the discovery and testing of transformers located in the river near the City of Cashmere does not suggest these are ongoing localized sources. While the possibility that additional transformers could exist in the river cannot be completely ruled out, this is a low priority for future investigations.

The main known sources of DDT to the Wenatchee River are within the Mission and Chumstick Creek sub-basins. Mission Creek has been studied previously and is listed separately on the 303(d) list as impaired for DDT, DDD, and DDE. Sampling conducted during this investigation used different methods than previous studies and should not be used for regulatory purposes. Chumstick Creek has not been studied previously and warrants further monitoring. Historic orchard activity within the Chumstick watershed has likely led to similar contamination of the soils as those measured in the Mission Creek watershed.

The inputs of DDT to the Wenatchee River are greatest during high-flow periods of the year (April to June). The irrigation returns sampled in this study contained measurable concentrations of DDT, compared with samples from the diversion points of the irrigation network. However, load calculations suggest these inputs are likely minor compared to the overall DDT load in the Wenatchee River. Loading calculations for DDT in the Wenatchee River revealed a possible unknown source somewhere between the United States Geological Survey (USGS) Peshastin gaging station and the USGS Old Monitor gaging station.

This study has established a firm understanding of the Wenatchee River food web and the transfer of PCBs and DDT to mountain whitefish (MWF). The diet of the MWF is selective (caddisflies and mayflies) and the location of the contaminated food source is confined to the lower Wenatchee. Therefore, MWF appear to be feeding and accumulating PCBs and DDT in the lower Wenatchee, a hypothesis which this study supports through the analysis of stable isotopic ratios of the Wenatchee River food web.

Recommendations

The findings of this initial source assessment provide some clear follow-up actions and opportunities for further investigation. The PCB and DDT sources are quite different and follow-up actions should be designed with this in mind.

PCBs

1. We have found two source areas of PCBs to the Wenatchee River. Using the same techniques as this study, further delineation within the possible source areas should be carried

out. This would include improved characterization of PCB loads during high- and low-flow conditions.

2. While it appears that stormwater may not be a dominant source of PCBs in the Wenatchee River it is important to verify this. Other river basins in Washington with urban areas have measured large contributions of PCBs in stormwater. Therefore the inputs of PCBs to the Wenatchee River from stormwater and wastewater in the cities of Cashmere and Wenatchee should be investigated.

3. Discuss the current 303(d) category listing for Icicle Creek and the Leavenworth/Peshastin sections of the Wenatchee River, which are currently category 5. This study has shown that while fish previously collected from these reaches exceed the Fish Tissue Equivalent Concentration (FTEC) water quality assessment level for the protection of human health for PCBs, the source of PCBs to the river is approximately 10 river miles downstream.

DDT

4. It appears that there is an unknown contribution of DDT to the Wenatchee River (between river mile 21 and 7), despite all of the major tributaries in the lower Wenatchee being sampled. Verification of the unaccounted DDT should be the first step in the investigation of the unknown DDT contribution.

5. DDT loads from the Chumstick Creek watershed were significant. The Washington State Department of Agriculture (WSDA) has an ongoing program monitoring pesticides in the Mission Creek watershed. It would be beneficial to both Ecology and WSDA to expand the monitoring of DDT to include Chumstick Creek and initiate the discussion of a strategy for the reduction of DDT from the Mission and Chumstick Creek watersheds.

Bioaccumulation

Continuing to understand the transfer of PCBs and DDT within the food web of the Wenatchee River will provide site-specific benchmarks and bioaccumulation factors. These will be important in monitoring the effectiveness of any remedial actions and in formulating a long-term source control plan for toxics in the Wenatchee River basin. In follow-up to this study, Ecology should:

1. Produce a complete bioaccumulation model for PCBs and DDT in the lower Wenatchee. A bioaccumulation model will allow for the prediction of water and biofilm concentrations necessary for fish tissues to be below the DOH fish consumption advisory targets for PCBs (46 µg /Kg) and the FTEC water quality assessment level for the protection of human health for PCBs (5.3 µg /Kg) and DDT (32 µg /Kg).

2. Confirmation of the life history and resident range of mountain whitefish (MWF) should be investigated through a collaborative fish tracking study with Washington Department of Fish and Wildlife (WDFW). It is important to understand whether MWF migrate between the upper and lower Wenatchee River and how long MWF in the lower Wenatchee spend in the contaminated reach of the river. Previous work by WDFW in the Wenatchee River basin has already established the necessary infrastructure for such a study.

Introduction

Over the last 10 to 15 years, some of the highest concentrations of polychlorinated biphenyls (PCBs) in fish tissue within Washington State have been found in the resident fish of the Wenatchee River, mainly mountain whitefish (MWF; *Prosopium williamsoni*). This has led to fish consumption advisories being placed on the river by the Washington State Department of Health (WADOH). As a result of concentrations of both PCBs and dichloro-diphenyl-trichloroethane (DDT) and DDT metabolites[1] (total DDT; herein referred to as t-DDT) in resident fish tissues, multiple reaches of the river are listed as impaired under the federal Clean Water Act, Section 303(d) (Table 1).

Table 1: Current 303(d) listings for reaches in the Wenatchee River impacted by PCBs and DDT.

Icicle Creek	Yaksum - Brender – Mission Creek	Wenatchee River	Columbia River
PCB[a]	4,4'-DDD[b]	4,4'-DDE[a]	4,4'-DDE[a]
	4,4'-DDE[a,b]	PCB[a]	PCB[a]
	4,4'-DDT[a,b]		

Note: Yaksum-Brender-Mission Creeks are listed as 4A (total maximum daily load in place)
[a] fish tissue
[b] water

As part of the process to reduce the concentrations of PCBs and DDT found in resident fish tissues in the Wenatchee River, the Washington State Department of Ecology (Ecology) initiated a source assessment study to identify and prioritize sources of PCBs and DDT to the river. The specific objectives of the study were: (1) to conduct an initial synoptic survey to assess the spatial distribution of PCBs, DDT, DDD, and DDE in the mainstem of the Wenatchee River, and (2) to identify and characterize sources of these compounds to the Wenatchee River, based on the results of the synoptic survey.

Contaminants of Concern

Polychlorinated biphenyls (PCBs)

History

Polychlorinated biphenyls (PCBs) are a class of 209 compounds or congeners which contain 1 to 10 chlorine atoms attached to two rings of biphenyl. There are a number of congener groups which are defined by the degree of chlorination, ranging from monochlorobiphenyls (1 Cl atom) to decachlorobiphenyls (10 Cl atoms), and referred to as *homolog* groups. Commercial and industrial applications of PCBs in the US relied on formulations of PCB mixtures under the trade name Aroclor. Each Aroclor is identified by a four-digit number, where the last two digits describe the % chlorine by weight (e.g., Aroclor 1254 contained 54% chlorine by weight).

[1] dichloro-diphenyl-dichloroethylene (DDD) and dichloro-diphenyl-dichloroethane (DDE)

PCBs were manufactured in the US from 1929 to 1977 and banned in 1979. However, they continue to be inadvertently and intentionally produced, because limited amounts are allowable under the 1976 Toxic Substances Control Act (Erikson and Kaley II, 2011). Their primary use was as an electrical insulating fluid, and also as hydraulic, heat transfer, and lubricating fluids. The bulk of PCBs were incorporated into capacitors (~50% by mass) and transformers (~25%) (Erikson and Kaley II, 2011). Additional minor applications were blends of PCBs and other chemicals as carbonless copy paper (~4%), plasticizers, and fire retardants. These blends have been used in many products, such as sealants, caulks, and adhesives and cumulatively represent ~ 9% of the PCBs produced. The numerous applications of PCBs as plasticizers and additives represent a much smaller PCB pool, but they do have a much greater circulation in the environment.

Environmental transport and fate

PCBs were created to resist degradation and persist, which has made them a ubiquitous environmental contaminant, despite many of their uses being in so-called *closed systems*. They are particularly soluble in lipids, leading to the accumulation of PCBs in biological systems. PCBs have been released into the environment mainly through volatilization into the atmosphere and spilling into waterways and onto land. In aquatic systems, sediments are an important environmental sink, while volatilization from water can be a significant loss from an aquatic system. Atmospheric losses of PCBs from lakes have received more attention in the scientific literature than losses from rivers (Honrath et al., 1997; Salamova et al., 2013); however, the loss of lighter PCBs from turbulent rivers could be significant.

The biodegradation of PCBs in sediments and soils is very slow (tens of years) and realistically does not represent a significant loss of PCBs in the environment (Sinkkonen and Paasivirta, 2000). In reality, PCBs are more likely to be redistributed and diluted within environmental media. The Aroclor PCB mixtures have different weathering rates because of the variable physical properties of the mixture of congeners. This may lead to an Aroclor mixture in the environment that is different than the original source. However, source tracking of PCBs based on the similarity to Aroclor mixtures has been undertaken with success, despite weathering (Rushneck et al., 2004; Rodenburg et al., 2015).

Bioaccumulation and toxicity

The bioaccumulation of fat-loving or lipophilic chemicals in aquatic organisms is dependent on the physical characteristics of the chemical and the exposure pathway. The factor by which PCBs bioaccumulate will therefore vary among locations and with congener composition. However, the factor can be quantified by the ratio of PCB concentration in the organism to total bioavailable (dissolved) concentration in the water. Similar to the way in which PCB congeners move between air, water, and soils; there is preferential biotic assimilation of heavier congeners (penta- and hexachlorobiphenyls), owing to lighter congeners being expelled during metabolism and heavier congeners binding more effectively to lipids (Fisk et al., 1998). However, heavier congeners can be limited during uptake due to physical characteristics and partitioning of the compounds.

PCBs are carcinogenic and can also affect the immune system, endocrine system, nervous system, and reproductive system. The most toxic have similar molecular structure to polychlorinated dibenzo-*p*-dioxins and are referred to as *dioxin-like*. To quantify the relative toxicity of these dioxin-like PCBs, the concentrations are often adjusted in terms of the toxic equivalence (TEQ), which is relative to the most toxic dioxin congener (2,3,7,8-tetrachlorodibenzo-*p*-dioxin).

Dichloro-diphenyl-trichloroethane (DDT)

History

DDT is an organochlorine insecticide that breaks down or is metabolized aerobically to dichloro-diphenyl-dichloroethylene (DDE) and anaerobically to dichloro-diphenyl-dichloroethane (DDD). Total DDT refers to the sum of DDT and metabolites. DDT was developed in 1874 and applied widely beginning in the mid-1940s when its insecticidal properties were discovered. It was used to help eradicate malaria and reduce insect damage on food crops. It has been used broadly in orchards to control codling moth populations. By the late 1950s and 1960s, concerns over its persistence and toxicity to non-target organisms led to the start of phasing it out. The EPA banned the compound in 1972; however, the chemical is currently applied in some developing countries.

Environmental transport and fate

DDT is highly hydrophobic but is highly soluble in oils, fats, and organic solvents. The stability of DDT and metabolites and the affinity for solids high in organic carbon have led to large sinks or deposits in agricultural soils that persist today. Bound DDT slowly redistributes mainly through the erosion of soils but also through volatilization and bioaccumulation. The half-life for DDT in soils can range from 2 to 15 years, but in the aquatic environment (sediments) can be around 150 years (Callahan et al., 1979).

Bioaccumulation and toxicity

DDT is poorly absorbed through mammalian skin (bioconcentration) but is easily absorbed through an insect's exoskeleton. In aquatic ecosystems, algae and sediments containing DDT provide the bioavailable mass of the contaminant to the upper trophic levels. DDT becomes concentrated in the fatty tissues of the predators. Bioconcentration factors vary among fish species and affect their tissue burden of DDT (Arnot and Gobas, 2006). DDT can be excreted and is metabolized in the organism to DDD and DDE. For organisms with DDT in fat stores that undergo periods of starvation, DDT metabolites are released into the blood where they can be toxic to the liver and nervous system. DDT is carcinogenic, can affect reproduction, and can be acutely toxic to aquatic organisms.

Potential Sources

Numerous possible sources of PCBs and DDT to the Wenatchee River were documented in the project planning stage, based on historical land use (Hobbs, 2014). A summary of these can be found in Tables A-1 and A-2. The priority potential sources for PCBs included: (1) former railway activities in the cities of Leavenworth and Wenatchee, (2) an anecdotal observation of a transformer in the river near the city of Cashmere, (3) the Leavenworth National Fish Hatchery, (4) upland contaminated sites, and (5) publicly owned treatment works (POTWs) and stormwater discharges. During this source assessment Ecology was able to investigate the first three of the possible sources and partially investigate the fourth potential source listed.

The possible sources of DDT to the Wenatchee River have been previously assessed in the Mission Creek sub-basin of the Wenatchee (Serdar and Era-Miller, 2004). Therefore, a goal of this study was to assess whether any additional major sources of DDT exist within the Wenatchee basin. The priority potential sources for DDT included (Table A-2) are: (1) irrigation returns, (2) historical land use and contaminated sites including former orchard lands, and (3) publicly owned treatment works (POTWs) and stormwater which receive wastewater and runoff from fruit packaging facilities. While DDT is no longer used in fruit growing, there is a small possibility of entrainment of contaminated soils from the orchard to the processing facility, which may discharge to the POTW. Sampling POTWs was viewed as a low priority and not part of this study. During this source assessment Ecology was able to assess the first two possible sources.

Previous Studies

During the project planning stage, there was a detailed overview of the previous studies documenting PCB and DDT contamination in the Wenatchee River basin (Hobbs, 2014; 2015). Prior investigations of PCBs in the Wenatchee River basin have documented contamination in water (MacCarthy and Gale, 1999; Sandvik, 2009; Morace, 2012), fish tissues (Hopkins et al., 1985; Era-Miller, 2004; Seiders et al., 2012a), and sediments (Ridolfi, 2011a; 2011b; Sloan and Blakley, 2009). The fish tissue data set is the most extensive on PCBs in the Wenatchee River and highlights a possible trend of higher concentrations in the lower Wenatchee and City of Leavenworth reaches (Figure 1).

Previous investigations in the Mission Creek sub-basin (Serdar and Era-Miller, 2004) and ongoing monitoring in Brender Creek within this sub-basin continue to show elevated concentrations of t-DDT (Sargeant et al., 2013). With the exception of the Mission Creek basin, there has been little additional sampling of the Wenatchee River for DDT. Similar to the PCB trends in fish tissue, t-DDT in fish tissue suggests greater exposure in the lower Wenatchee River (Figure 2).

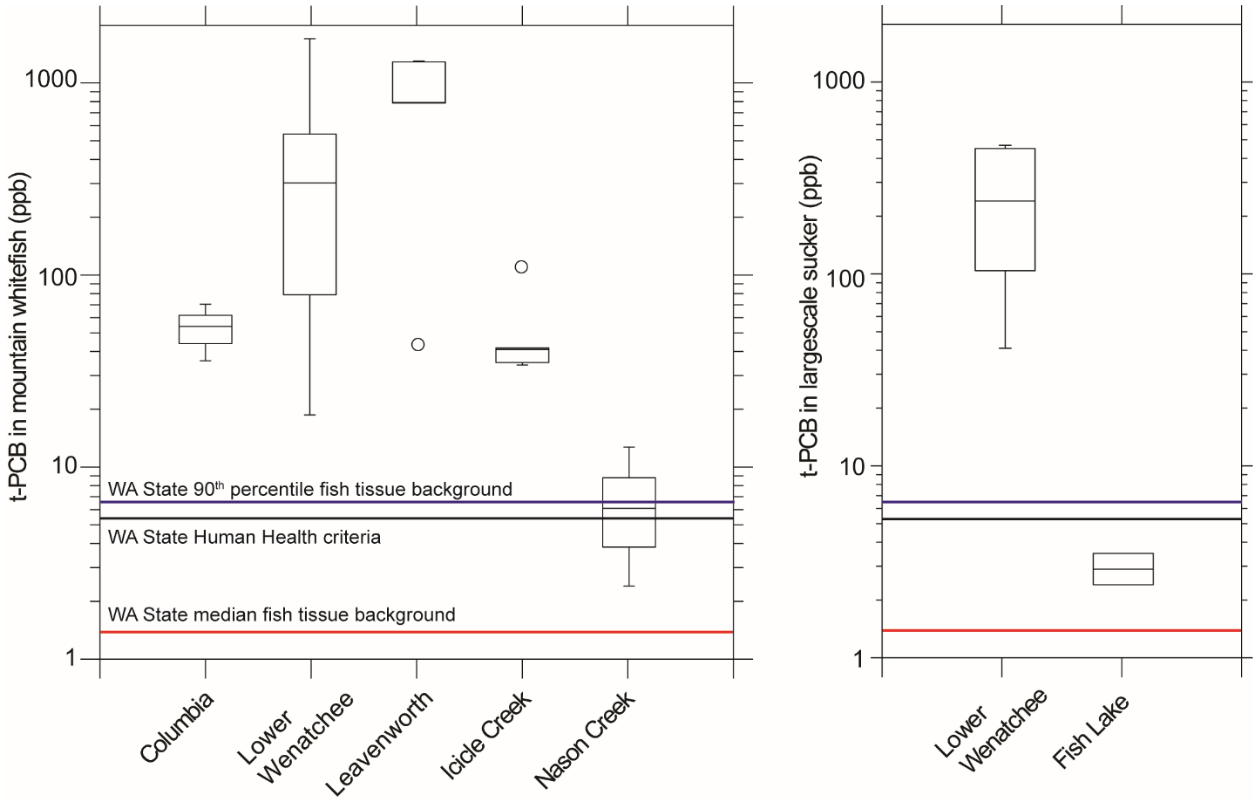


Figure 1: Historical t-PCB concentrations in mountain whitefish and suckers from the Upper (Nason Creek and Fish Lake) and lower Wenatchee River basin.

Data sources: Era-Miller, 2004 and Seiders et al., 2012a.

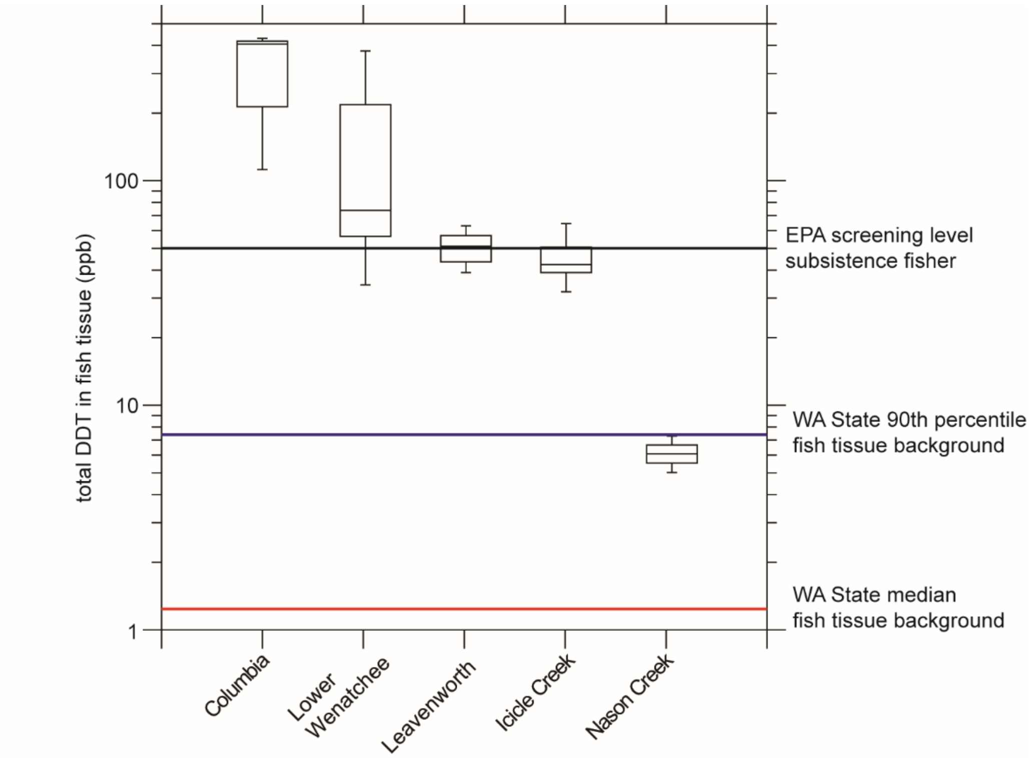


Figure 2: Historical t-DDT concentrations in mountain whitefish within the Upper (Nason Creek) and lower Wenatchee River.

Data Source: Era-Miller, 2004 and Seiders et al., 2012a.

Methods

Study Location

The Wenatchee River basin is situated in central Washington, on the east side of the Cascade Mountains. The basin covers approximately 1310 square miles (3400 km^2) and is bound by the Entiat Mountains to the north, Cascades to the east and the Wenatchee Range to the south. The Wenatchee River flows from headwater tributaries in the mountains to Lake Wenatchee, where it becomes the Wenatchee River at the outlet and flows 53 miles (85 km) to the confluence with the Columbia River (Figure 3). The river meanders on a gentle gradient from Lake Wenatchee until it flows through a deeply incised valley (Tumwater Canyon) to the town of Leavenworth. There the gradient lowers and the valley opens up. The river traverses a number of biogeoclimatic zones, with the major transition taking place near Leavenworth when the topography becomes lower relief (Figure 4). Much of the upper forested regions of the basin are part of the Wenatchee National Forest, managed by US Forest Service.

The geology of the basin is variable, comprising a number of different landforms ranging from the alpine and sub-alpine peaks of the Cascades to the low-lying Columbia plateau. The upper basin is underlain by metamorphic, sedimentary, and intrusive and extrusive igneous rock. Basalts and volcanic rock are present in the southwestern portion of the basin (Icicle Creek sub-watershed) and parts of the northern basin (Nason and Chiwawa Creeks). The lower portion of the basin below Wenatchee Lake to the west of Wenatchee River is composed of sedimentary rock of the Chumstick Formation. The Quaternary geology of the basin is dominated by three alpine glaciations, eroding the Wenatchee Valley and depositing moraines and outwash terraces with soil development during the intervening periods (Waitt Jr., 1977). The pro-glacial material of the lower Wenatchee also contains lacustrine sediments and signs that glacial floods have eroded much of the deposits. The tributary valleys contain alluvial material, and eroded alpine glacial drift is sporadically deposited throughout the upper and lower basin.

The climate of the Wenatchee basin is continental with hot, dry summers and cold, wet winters. Precipitation across the basin is variable, mostly falling in the winter as snow in the Cascade Mountain headwaters. Annual precipitation ranges from 82 inches at Stevens Pass (4,070 ft above sea level) to 9 inches at the city of Wenatchee (640 ft above sea level). Temperatures in Leavenworth range from 25 °F in the winter to 70 °F in the summer.

The hydrology of the Wenatchee River is nival-dominated (snow-dominated). Generally discharge peaks in May-June and low flow occurs in September.

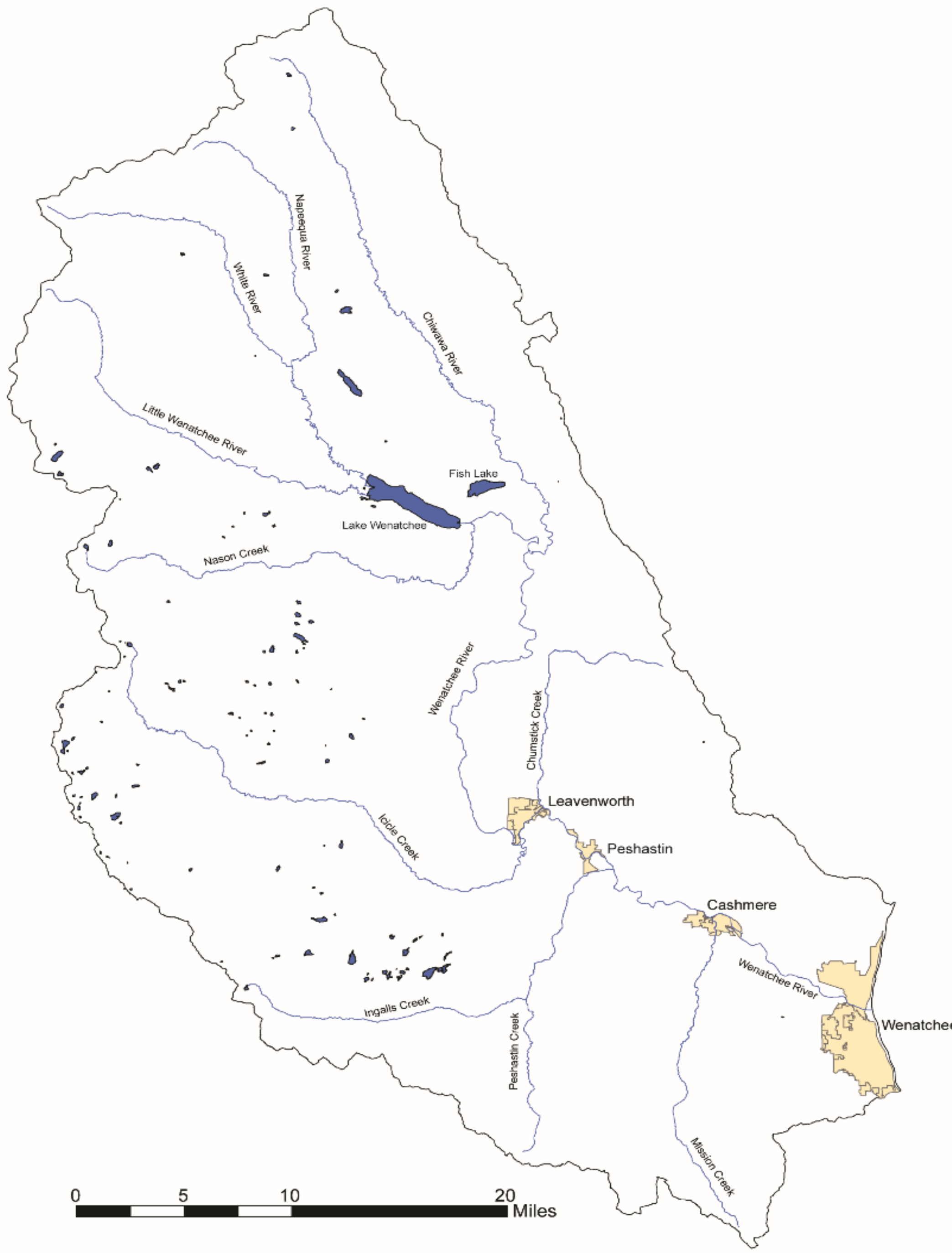


Figure 3: Wenatchee River basin (WRIA 45).

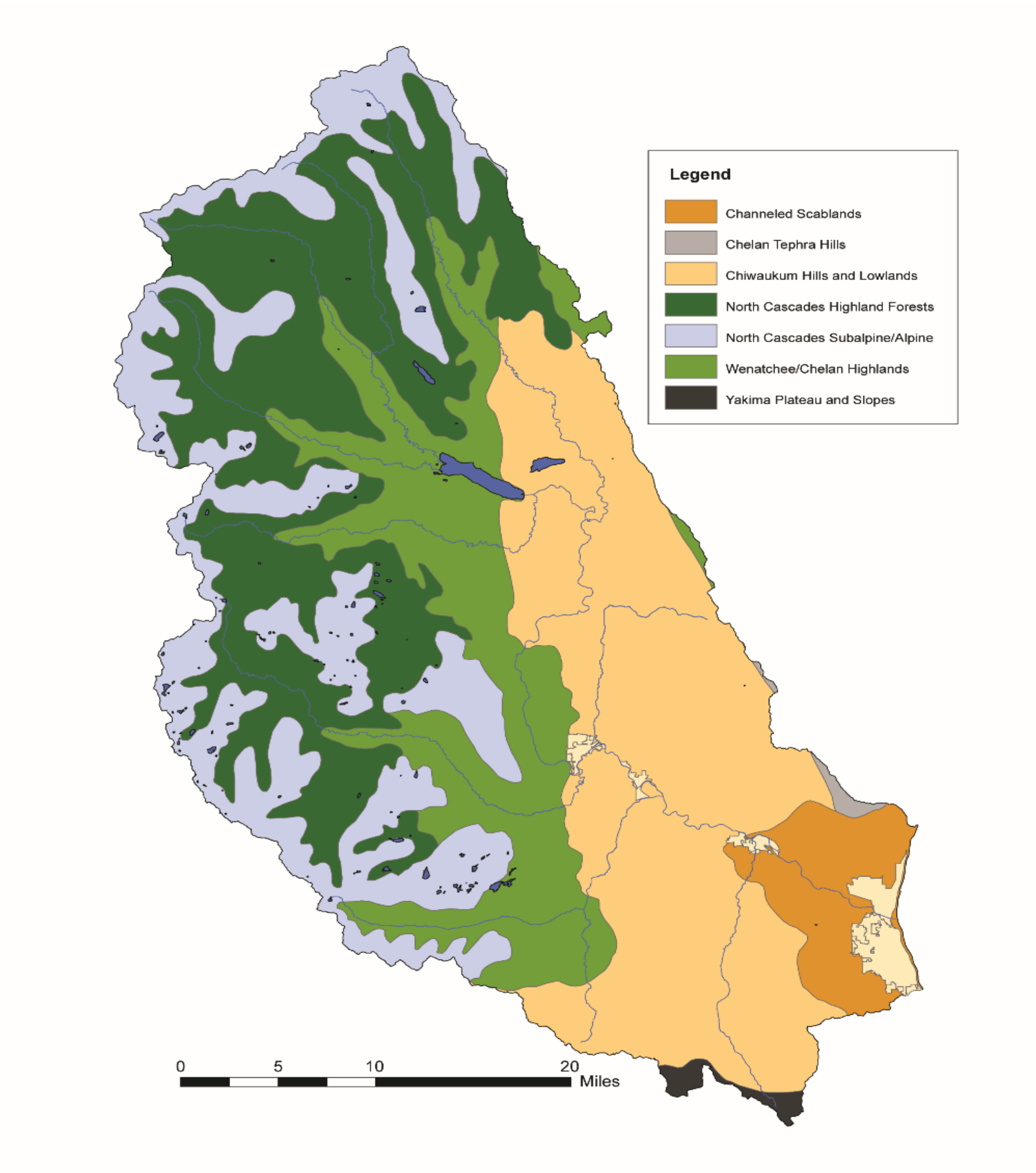


Figure 4: Biogeoclimatic zones of the Wenatchee River basin.

Sampling and Laboratory Methods

Sample locations for all media are detailed in Figure 5 and in Table B-1. All sample preparation and laboratory methods used in the study are detailed in Table B-2.

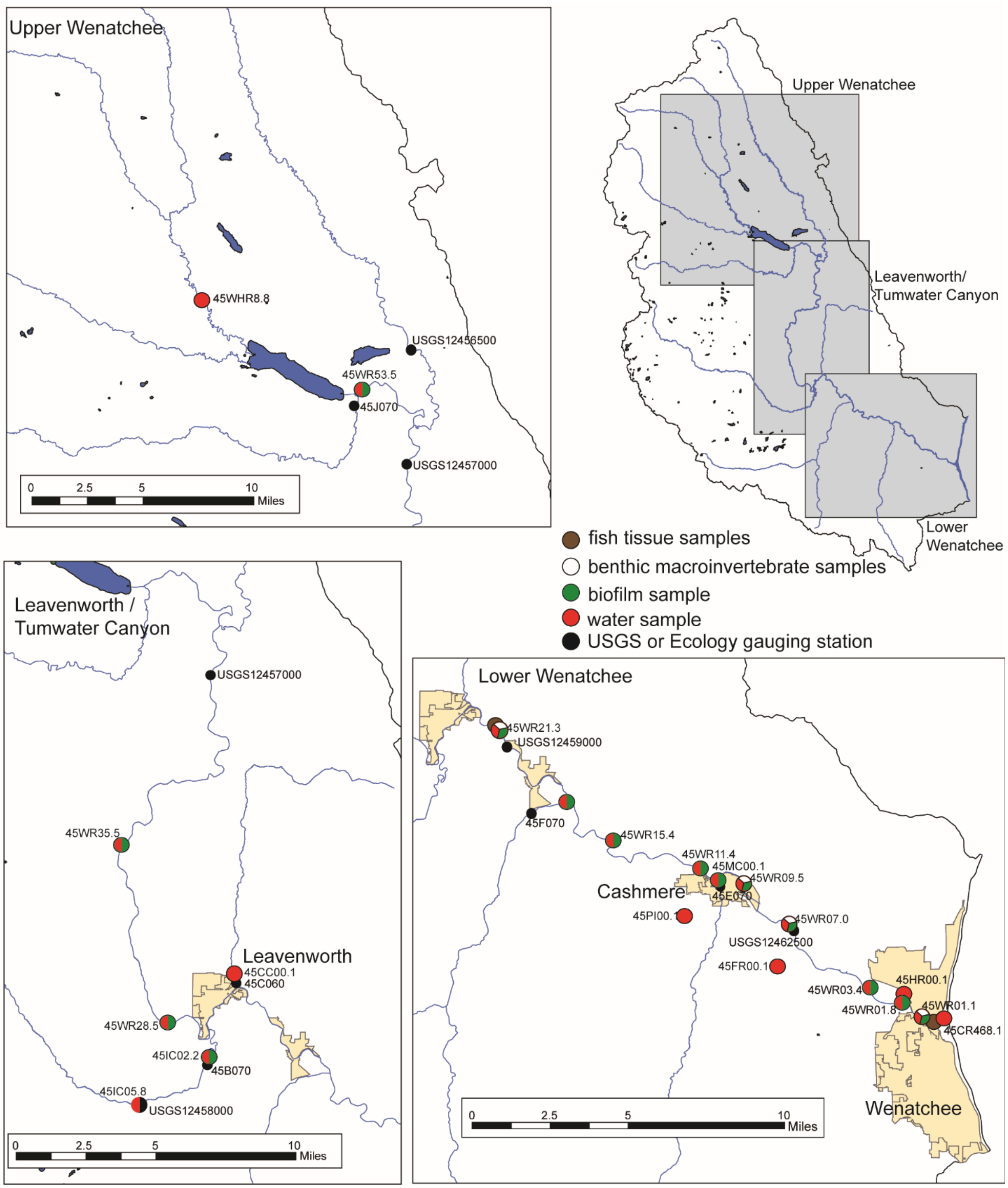


Figure 5: Sample site location map.
Note: some sites have multiple media sampled.

Water

Water was sampled using a number of active (e.g. grab and continuous low-level aquatic monitoring devices) and passive (semi-permeable membrane devices) sampling approaches. Grab samples were collected to measure conventional parameters. SPMDs and C.L.A.M.s were used to measure PCBs and DDT in water.

Surface water grab samples

Surface water grab samples were collected for the conventional parameters of total suspended solids (TSS), dissolved organic carbon (DOC) and total organic carbon (TOC). The parameters collected using grab approaches are used as ancillary data to help understand relationships between suspended matter and the organochlorine contaminants. Grab samples were collected using Ecology standard operating procedures (Joy, 2006).

Additional field parameters were measured *in situ* at the time of water sampling using a Hydrolab DataSonde (Swanson, 2007). Parameters included: temperature, pH, dissolved oxygen, and conductivity.

Semi-permeable membrane devices (SPMDs)

SPMDs are passive sampling devices and have been used by Ecology for a number of years (Seiders et al., 2012b). SPMDs are composed of a thin-walled, layflat polyethylene tube (91.4 cm x 2.5 cm x 70-95 um thickness) filled with 1 ml of triolein, a neutral lipid compound (Figure 6). The goal of any passive sampling device is to emulate natural biological uptake by allowing chemicals to diffuse through the membrane and concentrate over time (typically a 28-day deployment). After deployment, the membrane is removed, extracted, and analyzed for the organochlorine compounds of interest.

SPMDs were deployed in secure areas (i.e., to minimize vandalism and avoid strong currents), using stainless steel canisters and spindle devices provided by Environmental Sampling Technologies (EST). Each site canister contained 5 membranes that were preloaded onto spindles by EST and shipped in solvent-rinsed metal cans under argon gas. A StowAway® Tidbit™ temperature logger was attached to the canister to continuously monitor the water temperature during deployment. A second datalogger was attached nearby to monitor air temperature. The data collected from the temperature loggers are used to confirm that the SPMD remained submerged during the sampling period.

SPMDs were exposed for no more than 45 seconds at each site during deployment and retrieval. Nitrile gloves were used at all times. SPMDs were deployed for approximately 28 days in the spring and fall. The same cans were used during retrieval. They were properly sealed, cooled, and kept near freezing until arrival at AXYS Analytical for the extraction of the membranes (dialysis). Performance reference compounds (PRCs) were spiked into the membranes in order to assess biofouling and the non-equilibrium uptake of the compounds of interest (Huckins et al., 2006). The use of PRCs is essentially an *in situ*, site-specific calibration technique based on the observation that the rate of residue loss is proportional to the rate of residue uptake. The PCB congeners PCB-14, PCB-31L, PCB-50, PCB-95L, and PCB-153L were used as PRCs, where "L" denotes a ^{13}C labeled compound. PRCs were added at a concentration of 2.5 ng per SPMD.

Dissolved PCB congener and DDT concentrations were calculated from the mass extracted and measured from the SPMDs using the most recent USGS model (Alvarez, 2010; Alvarez, pers. comm.). The model is based on the octanol-water partition coefficient (MacKay et al., 1997), the physical properties of the SPMD, water temperature, and the length of deployment. Total PCB and DDT concentrations were estimated based on the formula (Meadows et al., 1998):

(1) $$C_{tot} = Cw\ (1 + [TOC]\left({}^{K_{OC}}/_{M_W}\right))$$

Where C_{tot} is the total contaminant concentration (pg L^{-1}), C_w is the dissolved concentration estimated in water (pg L^{-1}) from the USGS model, TOC is the total organic carbon concentration (mg L^{-1}), K_{oc} is the organic carbon-water partition coefficient (median value from MacKay et al., 1997), and Mw is the mass of water (10^6 mg L^{-1}).

Continuous Low-Level Aquatic Monitoring devices (C.L.A.M.s)

C.L.A.M. samplers are vessels for solid-phase extraction (SPE) disks, which are more commonly used in a laboratory setting to concentrate organic contaminants from large volumes of sample (EPA 3535). C.L.A.M.s contain a small, sealed pump behind the SPE that draws water through the device at an average rate of 30-60 ml per minute and is deployed for 24 to 36 hours. The SPE disks are shipped and secured in a high-density polypropylene cartridge. SPE disks were supplied by CI Agent Storm-Water Solutions, the supplier of the C.L.A.M. device.

C.L.A.M.s were deployed within the water column by tethering or anchoring to rebar or a cement block (Figure 7). The average deployment time was 28 hours during May 2015 and 65 hours during September 2015. Prior to deployment and upon retrieval, flow rates of the devices were assessed. Flow was measured with a graduated cylinder on the outlet port of the device and repeated until a consistent result was achieved. The water pumped through the device was captured in an adjacent container and the total volume was measured for calculation of contaminant concentrations.

At retrieval, the SPE disks were removed from the devices and cooled on ice. Disks were shipped to the analytical laboratory for extraction within 14 days. Using the mass (in grams) of organic compounds analyzed within the SPE and the sample volume, we calculated an average water concentration over the period of deployment.

Figure 6 (left above): An SPMD canister showing the upper membrane. Some biofouling on the membrane is evident.

Figure 7 (right above): A C.L.A.M. device deployed in a tributary to the Wenatchee River. The container in the foreground is used to collect the sample water for total volume.

Biota

Biofilms

Biofilm refers to the mixture of periphyton, microbial biomass, and fine sediments (Figure 8). Periphyton is algae attached to the river bottom, rocks, or debris in the river. We sampled biofilms in the Wenatchee River three times during the project (September 2014, May 2015, and September 2015) to assess the PCB and DDT concentrations bound to this matrix and evaluate the applicability of biofilms as a monitoring tool in source assessments.

Standard protocols were followed for sampling attached algae (Stevenson and Bahls, 1999; Mathieu et al., 2013). Biofilm was scraped from rocks and collected in a stainless bowl for weighing in the field to confirm that sufficient biomass had been retrieved. Samples were transferred from the bowl to a cleaned glass jar. A sample to assess areal biomass (g dry weight / cm^2) was collected separately; each rock scraped for biofilm was measured by cutting a piece of aluminum foil tracing the sample area. The aluminum foil was then measured at Ecology using the Image J software (Rasband, 2012).

Figure 8: Example of a biofilm being scraped from a rock.

Biofilms were analyzed for contaminant concentrations (PCBs and DDT), ash-free dry weight (areal biomass), and carbon (C) and nitrogen (N) abundance and stable isotope ratios. Stable isotopes are expressed as the ratio of the heavier isotope: lighter isotope relative to a standard (atmospheric N and Vienna Pee Dee Belemnite for C). The delta notation (δ) is used to express the very small variations in the isotopic ratios, such that:

(2) $$\delta^{15}N\ (‰) = \left(\frac{^{15}N/^{14}N_{sample}}{^{15}N/^{14}N_{reference}} - 1\right) \times 1000$$

The same formula is used to express the $\delta^{13}C$ for the heavier ^{13}C isotope to the lighter ^{12}C. Prior to C and N analysis, biofilms were freeze-dried at Manchester Environmental Laboratory (MEL). An aliquot of the biofilm was also qualitatively identified under a microscope to roughly assess community composition.

Invertebrates

Invertebrates were sampled in September 2015 in a number of locations in the lower Wenatchee River and in May and September 2015 in the stomachs of a number of mountain whitefish (MWF) to assess diet. Samples from MWF stomachs were extracted from the fish and placed in formalin while in the field. Back at the lab, samples were rinsed and placed in alcohol for storage and identification. Once the predominant diet of MWF had been assessed, the same genus or functional feeding group was targeted for collection by picking individuals from rocks in four locations including an upriver background site (USGS Peshastin gaging station).

Invertebrates (caddisflies and mayflies) were removed from their casings, and sufficient biomass for analysis was assessed in the field using a scale. Invertebrate tissues collected from the four river locations were analyzed for PCBs, DDT, C, and N.

Mountain whitefish

Mountain whitefish (MWF) were sampled in May and September 2015 at the confluence with the Columbia River and upstream near the USGS Peshastin gaging station (adjacent to the Osprey Rafting Co. site). MWF were collected using electrofishing techniques at the confluence and hook and line at the upstream site. Fish were collected for both composite fillet samples to compare to FTECs and individual whole fish to assess stable C and N isotopic ratios of the tissues and PCB and DDT concentrations. Due to budgetary constraints, chemical analysis of the tissues were analyzed under a different project (Seiders, 2015) and are not reported here. The isotopic ratios of the tissues are used to infer trophic position (Post, 2002) and assess feeding location.

Sediment

One sediment sample was collected in a backwater area of the Wenatchee River near the confluence with the Columbia River. This is the only area of the Wenatchee River bed that has appreciable fine sediment accumulation. The sample was taken to assess the concentrations of PCBs and DDT in these reclaimed backwater areas that are part of Confluence State Park. The sediment sample was collected from canoe in May 2015 using a petit ponar dredge sampler (Blakley, 2007). The upper 2-3 cm of surface sediment was collected from 5 grabs and homogenized in a stainless steel bowl.

Quality control procedures

Measurement quality objectives (MQOs) for this project were defined during the project planning stage (Hobbs, 2014; 2015; Table C-1). All laboratory quality assurance / quality control (QA/QC) measures are documented in MEL's Laboratory Quality Assurance Manual (MEL, 2012). Laboratory quality control measures include the analysis of check standards, duplicates, spikes, and blanks and are documented in the quality assurance project plan (QAPP) for this study (Hobbs, 2014). The tracking and calculation of check standards, spikes, and blanks for the SPMDs followed the SPMD SOP (Seiders et al., 2012b) and SPMD data management SOP (Seiders and Sandvik, 2012). SPMDs require a detailed method blank procedure that is carried out by both AXYS Analytical and MEL. The following method blanks were prepared by EST:

1. A spiking (method) blank - SPMD exposed while spiking the SPMDs, to represent laboratory background. This blank is held frozen at EST and later dialyzed with project samples.
2. A construction (day-zero) blank - SPMD from the same lot as the project batch, to represent background. Generally spiked with performance reference compounds.
3. A membrane (matrix) blank - a single membrane from the same lot as the project batch, not spiked.

Field trip blanks were used for the SPMDs and C.L.A.M. samplers. The field blank SPMD was taken into the field and exposed for the same duration of time the sample SPMD was exposed to the air during deployment. The blank was sealed, transported cold back to Ecology, and stored frozen. The blank was then taken back into the field and exposed to air for the same duration as the sample SPMD during retrieval. In 2014, one field blank, one membrane blank, and one construction blank (a day-0 blank) were used to assess background contamination in SPMDs. In 2015, two field blanks and a construction blank were used for SPMDs.

The field blank SPE for the C.L.A.M. device was taken into the field and the Luer locks were opened, exposing the SPE media. The SPE media was exposed for the same duration as C.L.A.M. deployment and retrieval. One SPE field blank sample was taken for each sampling trip. Additional method blanks were carried out to assess the possibility of equipment contamination, they included:

1. A raw media blank – the SPE media (C-18 composition) is analyzed separately from the disk housing.
2. A disk blank – the SPE media and polyethylene disk housing is conditioned and extracted as a method blank.

During the May 2015 sampling event, three disk blanks and one raw media blank were analyzed.

Results

Quality Assurance

All quality assurance data are detailed in Appendix C. All laboratory recoveries, internal standards, data censoring, equipment performance, and laboratory narratives were reviewed by Ecology's Manchester Environmental Laboratory quality control officer, Karin Feddersen. All the laboratory electronic data deliverable spreadsheets can be downloaded from the Ecology publication page for this report (Appendix F), see the *Publication and contact information* page at the beginning of this report.

Blanks

Blank samples are particularly relevant to the C.L.A.M. and SPMD samples. These results are used to determine the level of background contamination in the equipment or in the field caused by exposure to the atmosphere. These blank samples are also used to quantify the suitable site-specific method detection limits (MDLs) and method quantitation limits (MQLs) for the SPMDs (Seiders and Sandvik, 2012). This estimation is based on the mean blank concentration plus three times the standard deviation among the blanks for MDLs and the mean plus ten times the standard deviation for MQLs (Seiders and Sandvik, 2012).

The blanks for the SPMDs comprised both field and construction (day-zero) blanks. During the September 2014 SPMD sampling we calculated an MQL of 59.3 pg/L for PCBs and 6.5 pg/L for DDT (Table C-2). The September 2015 sampling had an MQL of 38.2 for PCBs and 13.1 for DDT. We used the MQLs to censor our estimates of water concentrations.

The C.L.A.M. devices were treated slightly differently. Here we calculated the MDL and MQL based on the concentration present in solid phase extraction (SPE) disk (pg/sample or pg/S) and not as an estimated water concentration (pg/L). During the May 2015 survey using the C.L.A.M. device we found significant PCB contamination in the device disk housing (Table C-2). It appears that the polyethylene housing is contributing PCBs to the sample. Unfortunately, this rendered all of our samples as unacceptable and the data could not be used. Blank contamination for DDT was not an issue for the C.L.A.M. sampler, and we found an MQL of 457.7 pg/S for the May 2015 sampling and 396.4 pg/S for the September 2015 sampling (Table C-2).

Blank samples were also run in association with all other parameters and media to determine if the laboratory environment contributes any contamination. All results indicated no detectable contamination was present.

Precision

Precision is assessed by the analysis of sample replicates (Table C-3). Field replicates were collected during each sampling event at a frequency of no less than 10% of the total sample number per sampling event. All grab samples taken for conventional parameters met the MQOs for the study (Hobbs, 2014), with the exception of one TSS sample from September 2015. We did not use the high value reported for the TSS replicate based on previous September samples and field observations.

The SPMD precision MQOs were not met for PCBs. The relative percent difference (RPD) between sample replicates was 74% and the MQO was ± 20%. Precision in SPMD studies for PCB congeners has either proven difficult in previous studies (McCarthy and Gale, 1999) or has met MQOs in some studies (Sandvik, 2009). Our replicate SPMDs were located approximately 20-30 feet apart and therefore the variability in the data could reflect variability of the river and differences in biofouling. Future replicate deployments should be within 1-2 feet and not obstructed. We chose to use the average of the replicate data points in our interpretation, which does not affect our ability to detect increases in PCB concentrations at the scale of an order of magnitude. C.L.A.M. replicate samples were within the study MQOs.

The precision of the biofilm results were well within the study MQOs for organic content, lipids, and PCBs. The tissue samples analyzed for N and C stable isotopes and concentration (%) were run as replicates or triplicates for each sample because of the small sample mass required and heterogeneity of using small sample masses (Table C-4). Independent quality control reference materials were analyzed with each run, to assess the laboratory accuracy and precision. Accuracy for the $\delta^{15}N$ ranged from 0.02 to 0.12 per mil or ‰ (median of 0.06 ‰) and $\delta^{13}C$ ranged from 0.02 to 0.06 ‰ (median of 0.04 ‰). Precision for the $\delta^{15}N$ ranged from 0.005 to 0.08 ‰ (median of 0.05 ‰) and $\delta^{13}C$ ranged from 0.03 to 0.13 ‰ (median of 0.06 ‰).

The RPD between replicates or the relative standard deviation (RSD) among triplicate samples, was generally less than 5% for all isotope analyses. The RPD or RSD for %N and %C was above 20% for a few biofilm samples which was mainly due to low % abundance in some samples and heterogeneity of the sample in other cases. When a sample RSD was greater than 20% the results were assessed for an outlier and the remaining samples were averaged for the sample result. Results where RPDs were well above 20% were also assessed for unrealistic values and then values were removed. The remaining replicates were averaged for the sample result.

Bias

Bias is assessed by measuring the recovery of analytes using laboratory spikes. In general, all method specifications for PCB and DDT high resolution methods were met. The analysis of DDT in the 2014 SPMD samples was observed to have high recoveries (results biased high) when compared to the contract lab's limits, but were within EPA's Method limits. No other issues were noted with laboratory spike recoveries during the analysis of other parameters or matrices.

The recovery of spiked compounds is also used for the SPMDs to assess the rate of uptake of organic contaminants. These PRCs are introduced to the SPMDs during manufacturing and their recovery is measured following deployment. A range of PRCs with varying molecular weights are used and they are expected to attenuate from the SPMD during the deployment period. In general, the percent PRC remaining in each of the SPMDs was within the expected range (Table C-5). As expected the higher weight PCBs did not attenuate below 90%. Furthermore, at one site (45WR01.1) there was an accumulation of PCB-50 above the original amount added to the membrane suggesting that this congener is found in the environment. PCB-50 is used as a PRC because it is thought not to be present in the environment. PRCs that did not show attenuation during deployment were not used in the model for water concentrations.

Sensitivity

Sensitivity is described by the estimated detection limit for each parameter and data are censored accordingly. Required detection and quantitation limits under the project plan (Hobbs, 2014) were met for all the parameters analyzed.

Water

Discharge

Typically the Wenatchee River experiences higher flows from April through July and the lowest flows during August through October (Figure 9). The 2014 water year generally followed the normal trend of the previous decade, but with higher than normal flows in November and December (Figure 9). The discharge record for 2015 was abnormal and characterized by higher than normal flows in January through March and lower than normal flows from May through September. Sampling periods in September 2014 and 2015 were during low flow regimes, while the May 2015 sampling event was during high flow.

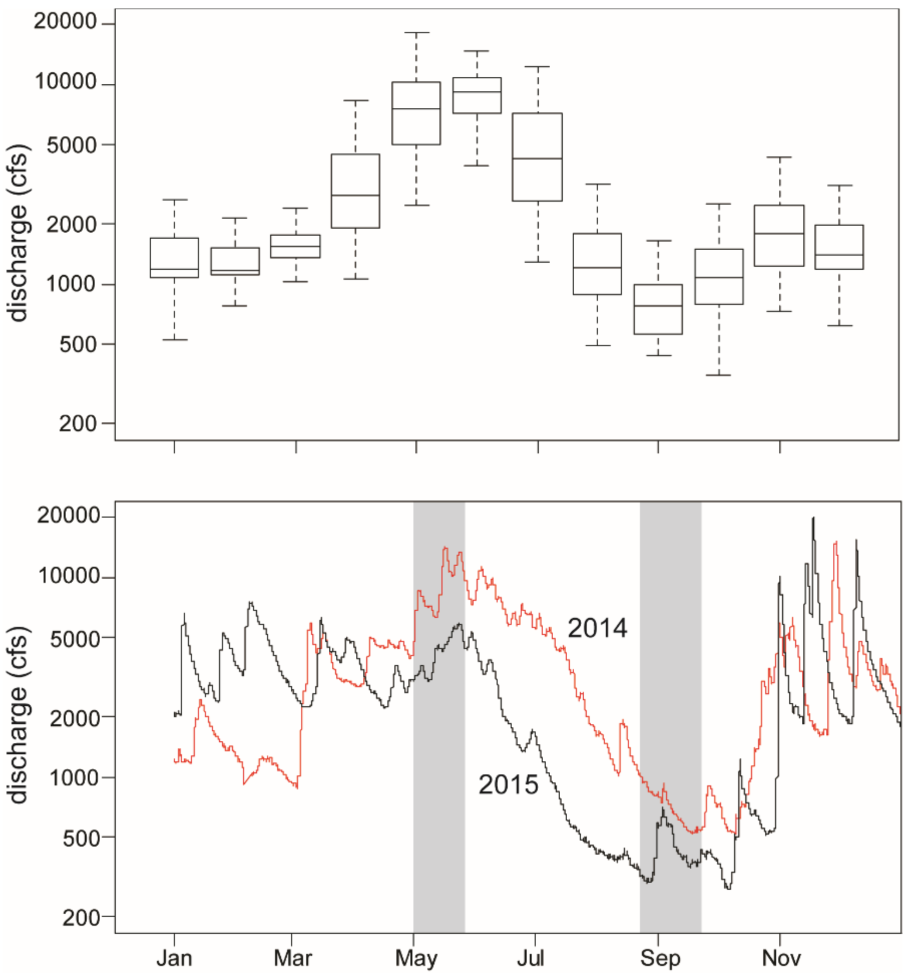


Figure 9: Hydrology for the Wenatchee River.

Upper plot is the monthly summary of discharge data since 2007 and the lower plot summarizes the sample years. Shaded regions of the lower plot indicate the sampling periods. Source of data is USGS station 12462500.

Semi-permeable membrane devices (SPMDs)

The initial survey using SPMDs in September 2014 targeted 9 sites throughout the Wenatchee River basin. The SPMDs were successfully deployed and retrieved over a period of 27-29 days. All samplers remained submerged during deployment, as confirmed by temperature loggers. The follow-up SPMD survey took place in September 2015 and consisted of 9 sites in the lower Wenatchee River basin. All samplers remained submerged for the duration of the deployment.

PCBs

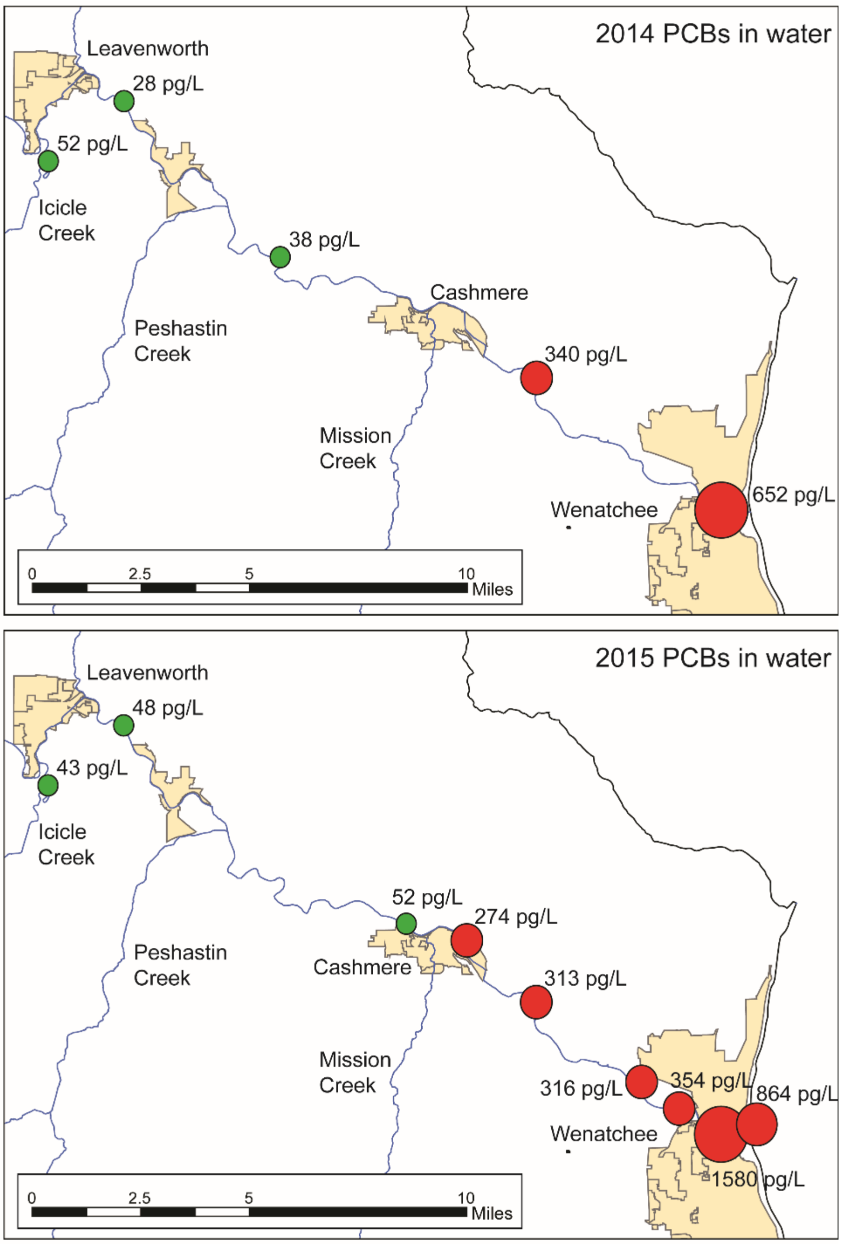


Figure 10: Estimated PCB concentrations in water from SPMDs.

Green dots are not above the equipment background and red dots are scaled in size to the concentration.

Using the blank QC sample results, we defined a background PCB contamination in the SPMDs equivalent to an estimated concentration of 59 pg/L during the September 2014 sampling. There were 2 sample locations in 2014 with concentrations elevated above the background, Old Monitor (340 pg/L) and under the Hwy 285 bridge (652 pg/L) (Figure 10; Table D-1).

During the September 2015 SPMD survey, we targeted the reach of the river from the City of Cashmere, downstream to the confluence with the Columbia River. During this sampling, a background estimated concentration of 38.2 pg/L was calculated. The six downstream sites were above the background (Figure 10). Estimated t-PCB concentrations at the Old Monitor bridge site were similar between 2014 (340 pg/L) and 2015 (313 pg/L).

Concentrations were fairly consistent downstream of Cashmere, until the Hwy 285 bridge when there was an additional increase.

DDT

DDT was assessed basin-wide during the 2014 SPMD survey (Table D-2). Background contamination SPMD concentrations were estimated at 7 pg/L. All study locations had estimated concentrations above background contamination. Concentrations in the upper Wenatchee, Tumwater Canyon, and Icicle Creek ranged from 23 to 33 pg/L and represent an ambient range for the Wenatchee River. The site downstream of the Chumstick Creek input showed an increase to 106 pg/L (Figure 11). Total DDT concentrations increased again downstream of the Peshastin Creek input (343 pg/L) and remained stable until the sample site near the confluence with the Columbia River (1774 pg/L).

The 2015 SPMD survey measured t-DDT at three of the downstream sites. All three sites had comparable concentrations (Figure 11). This finding differs from the 2014 survey and is possibly related to a slight increase in flow during September 2015, which would result in an increase of inputs from tributaries such as Mission Creek (Figure 11).

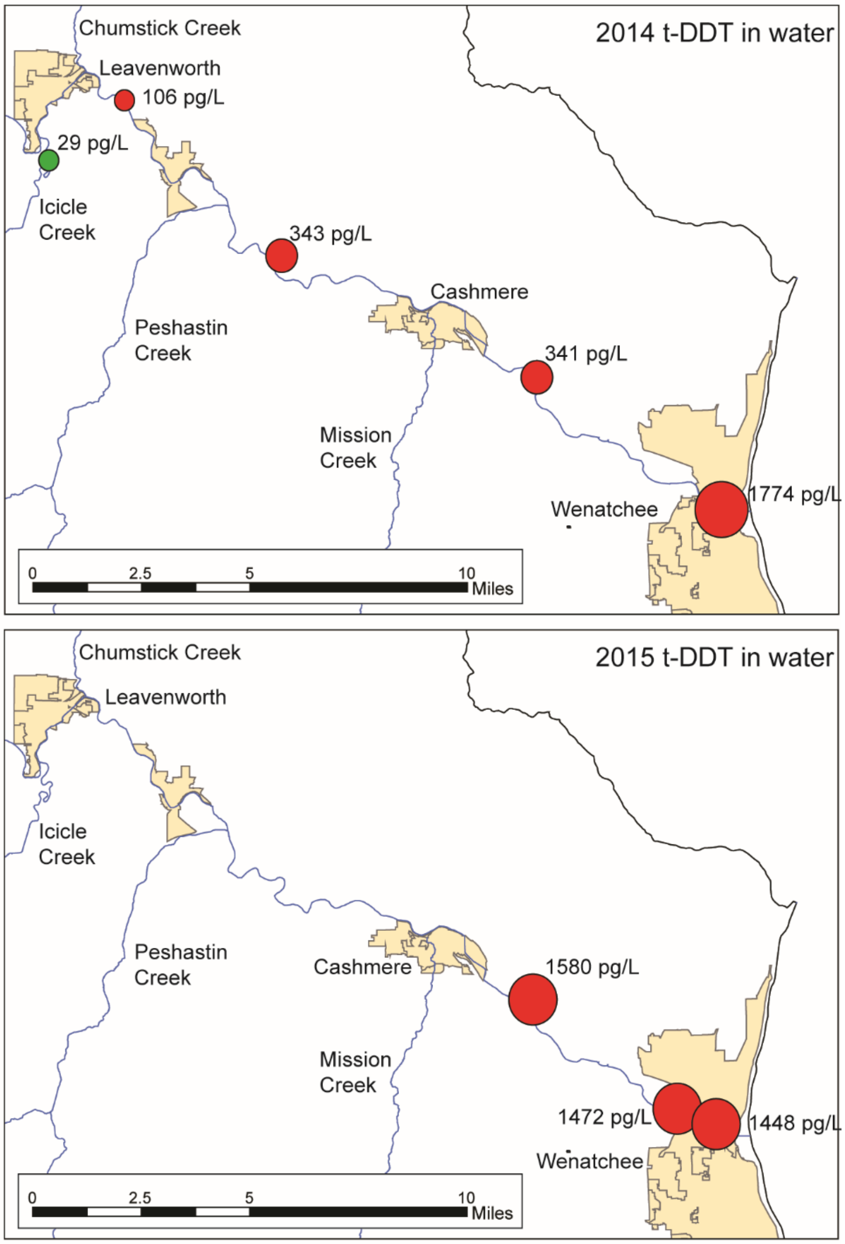


Figure 11: Estimated DDT concentrations in water from SPMDs.

Green dots are not above the environmental background and red dots are scaled in size to the concentration.

Continuous Low-Level Aquatic Monitoring devices (C.L.A.M.s)

PCBs

C.L.A.M. devices were used during the May 2015 sampling. Cost savings was the primary motive to switch from SPMDs to C.L.A.M.s, and the smaller devices are more suitable for sampling in tributaries. Because of the significant equipment contamination found in the casing of the C.L.A.M. solid-phase extraction disk housing, the survey data were rendered unusable. One site, in a backwater area at the confluence with the Columbia River, was somewhat above the noise of the equipment contamination (Table D-4).

DDT

The C.L.A.M. devices were successfully used to measure t-DDT concentrations during the May 2015 survey. Estimated concentrations from samples in Icicle Creek and near the USGS Peshastin gaging station (45WR21.3) were not greater than the level of contamination found in the equipment. Of the major tributaries to the lower Wenatchee River (Icicle, Chumstick, Peshastin, and Mission), Chumstick and Mission Creeks had the highest concentrations (Table D-4). Detectable concentrations of t-DDT were also observed in the three irrigation returns sampled, ranging from 942 pg/L to 10,410 pg/L. It should be noted that concentrations of t-DDT prior to the diversions for these irrigations systems (Icicle Creek and the Wenatchee River near Peshastin) showed low estimated concentrations, 12 pg/L and 21 pg/L respectively.

Sampling in September 2015 using the C.L.A.M. devices focused only on the tributaries and irrigation returns. Compared to the May sampling, concentrations were lower during September, and Chumstick and Mission Creeks continued to have the highest concentrations (Table D-4). Irrigation returns continued to show detectable concentrations of t-DDT. Comparisons of DDT loads from tributaries and irrigation returns are discussed in later sections.

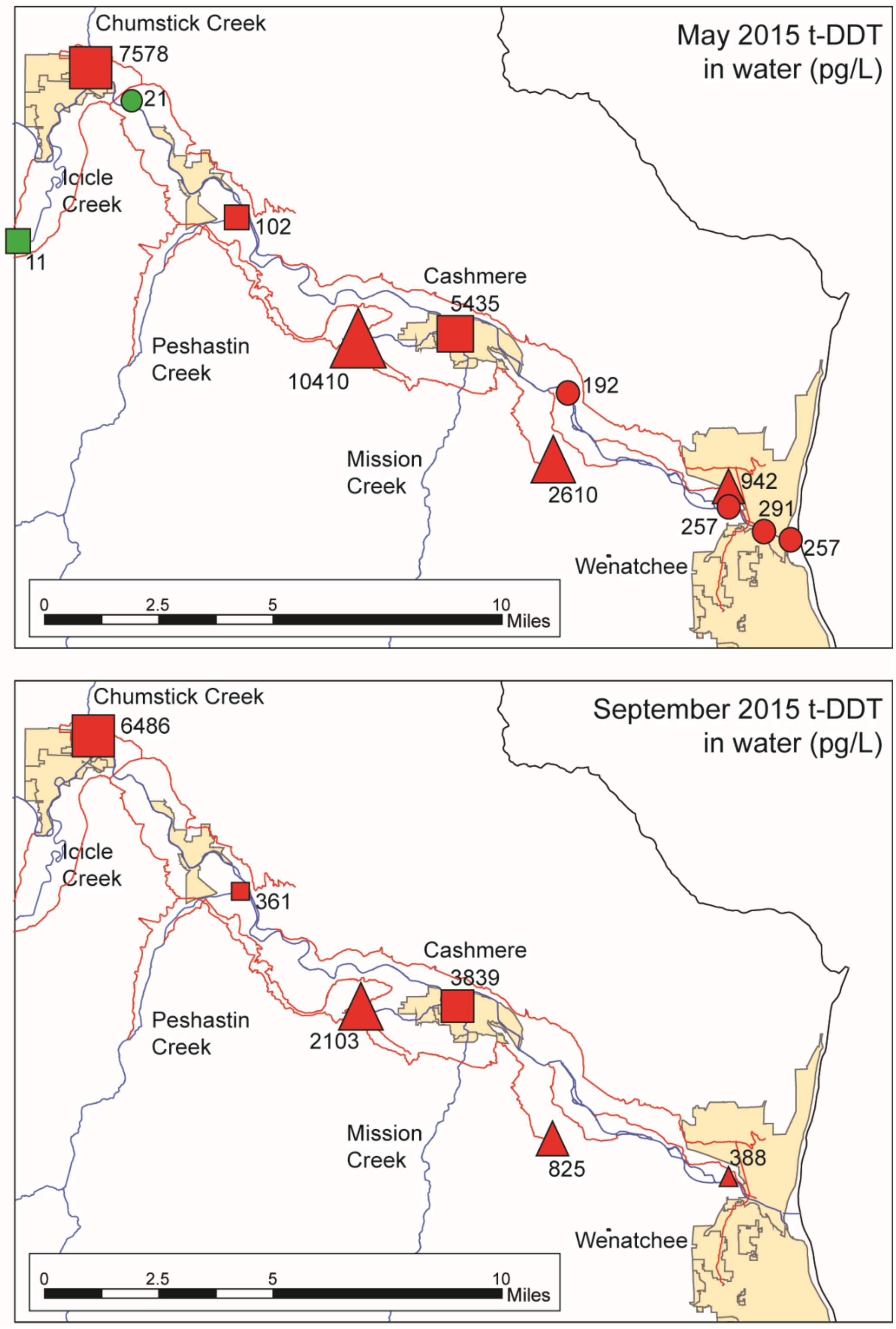


Figure 12: Estimated DDT concentrations from C.L.A.M. samplers.

Red lines are the irrigation canals. Circles (●) represent Wenatchee River samples; squares (■) represent tributaries; and triangles (▲) represent irrigation returns. Green = below background, red = above background.

Biota

Biofilms

This investigation has provided an opportunity to verify the utility of using biofilms on the river substrate as a monitoring tool or media to spatially assess the presence of PCB and DDT contamination. The main focus was on PCB contamination due to budgetary constraints. We co-located SPMDs and biofilm sampling sites in order to compare the contaminant burdens of dissolved PCBs and DDT in water to PCBs and DDT in biofilm tissues. Over the course of the study, 14 sites were assessed for PCBs. Some were sampled in both 2014 and 2015. Only one site was assessed for DDT. The strongest relationship between PCBs in biofilms and estimated dissolved PCB concentrations in water was found when biofilm concentrations were normalized to organic carbon content. Fitting a linear relationship through the data gives a strongly significant correlation ($r^2_{adj} = 0.95$; $p < 0.001$). This suggests that PCB burdens of the biofilms are strongly representative of dissolved PCB concentrations in the water. This is further supported when looking at the two matrices from headwater to confluence with the Columbia River (Figure 13).

Comparing the congener profiles from 2 different sites for dissolved PCBs in water and PCBs in biofilms shows a very strong similarity in the composition of the PCBs between the two matrices (Figure 14). The partitioning and uptake of PCBs by algae has been explored in phytoplankton in lakes (Swackhamer and Skoglund, 1993; Stange and Swackhammer, 1994) and appears to vary with K_{ow} where lighter congeners may reach equilibrium at a faster rate. The same level of research on the uptake of PCBs by biofilms has not been undertaken. In reality, there is likely substantial binding and adherence of PCBs to the polysaccharide sheath produced by diatoms and the microbial biomass that is part of the biofilm. It is unknown whether PCB compounds are too complex to be incorporated into the cell structure of the diatom or algae.

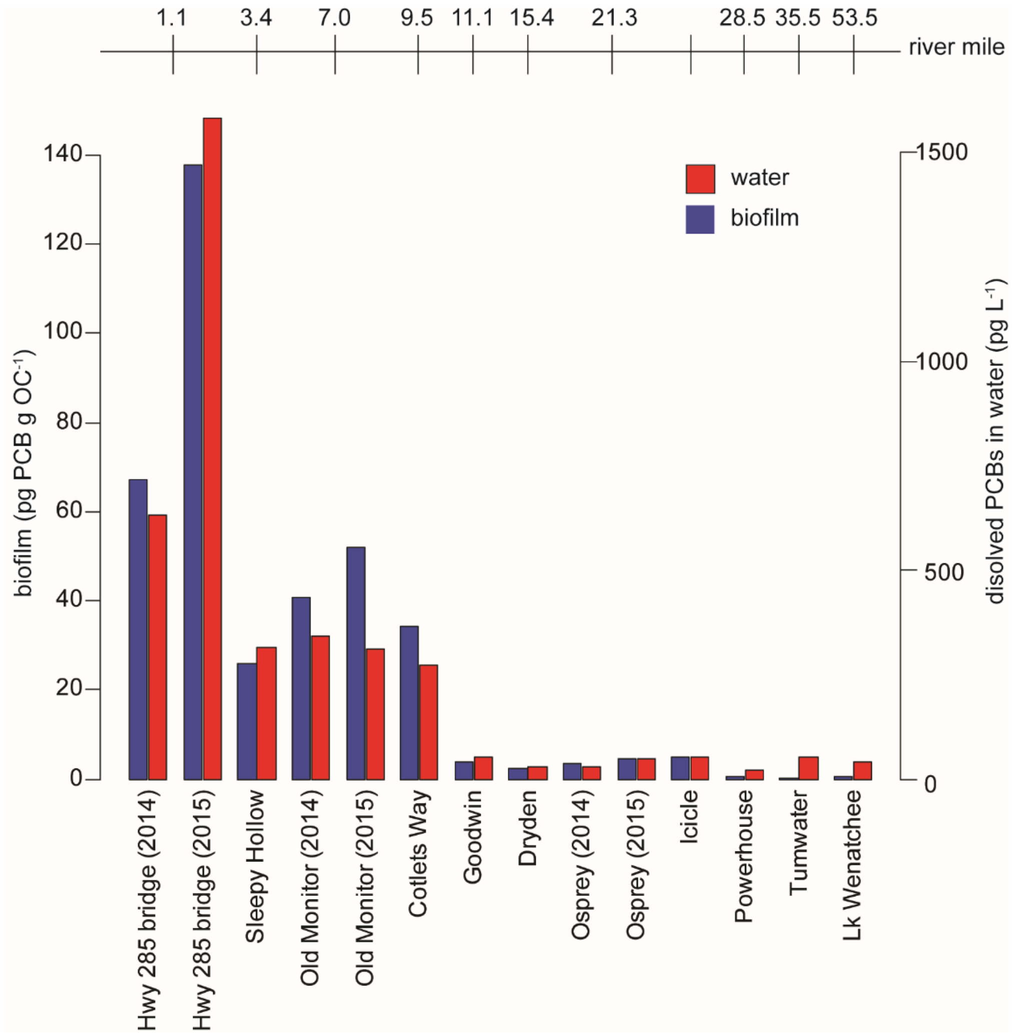


Figure 13: PCBs in biofilms and estimated dissolved concentrations in water from SPMDs at each site from the upper Wenatchee River (right) to the lower Wenatchee (left).

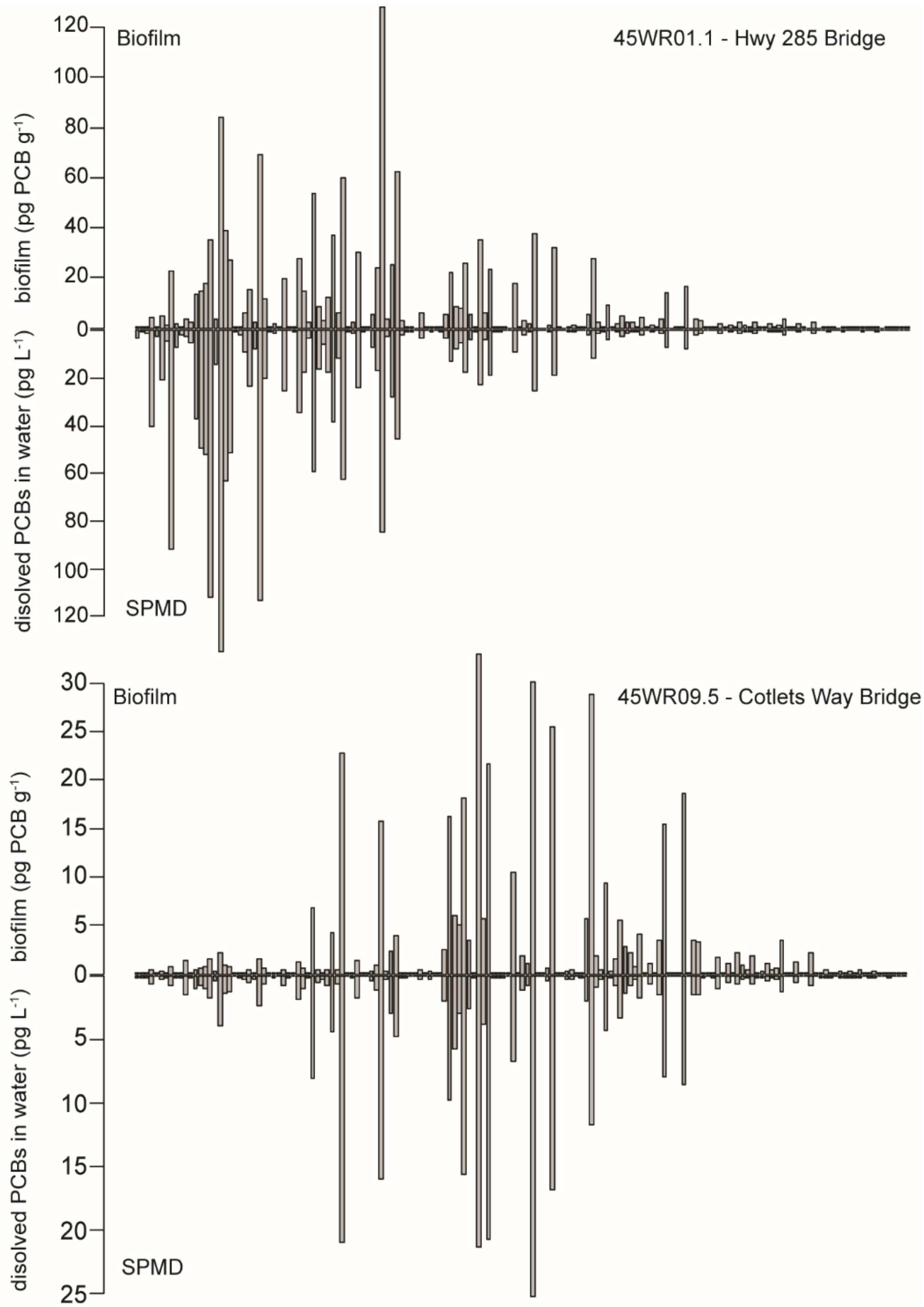
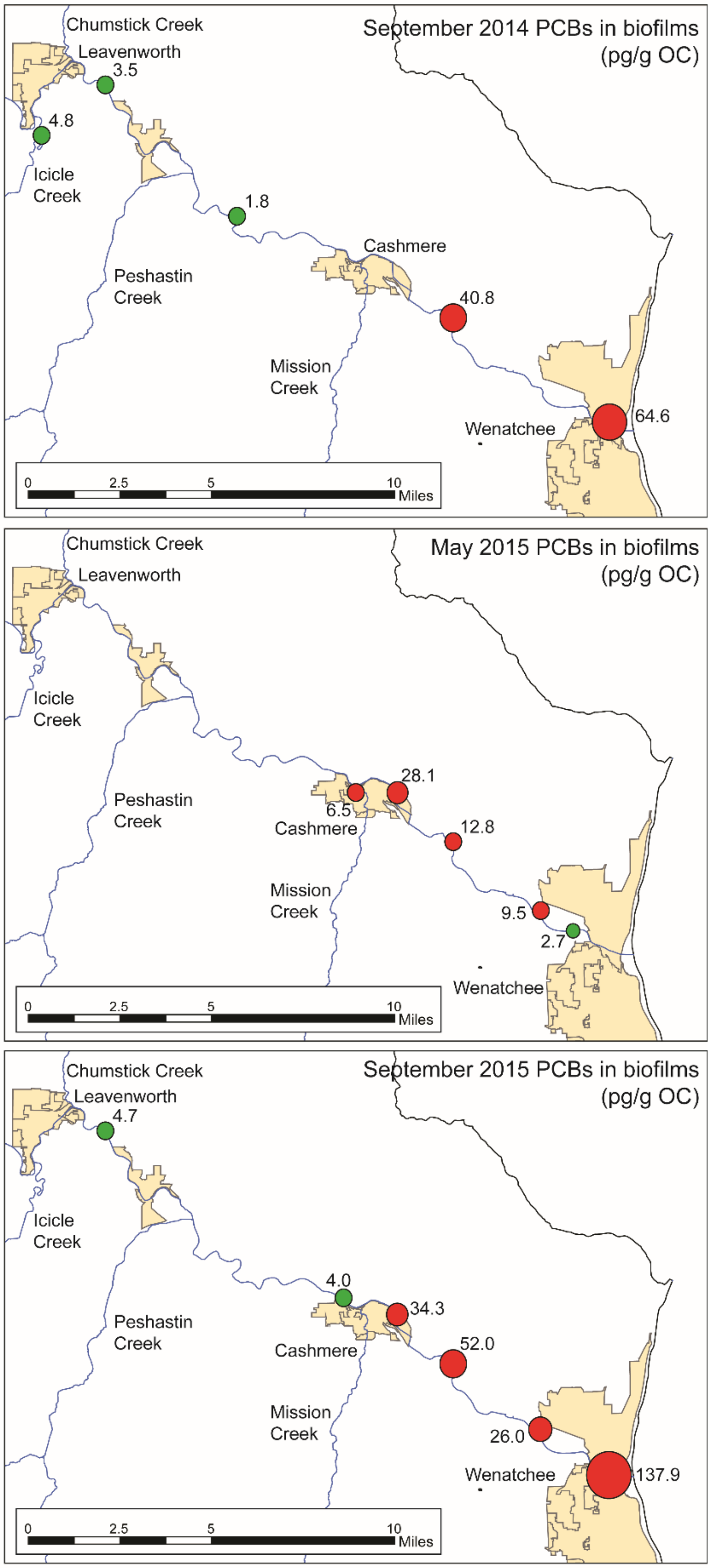


Figure 14: Congener profiles of estimated dissolved PCB concentrations from SPMDs and biofilms.

The x-axis represents PCB congeners from 1 to 209 (left to right).



Looking at the concentrations of PCBs in biofilms over the three sampling events strongly supports the SPMD results presented in the previous section (Figure 15). An ambient concentration of approximately 5.0 pg / g OC was observed over the 2014 and 2015 surveys, based on the upper Wenatchee River biofilm concentrations (Table D-6). During the 2014 low-flow sampling, the two downstream sites were above the ambient concentration (Figure 15).

The May 2015 sampling event during high-flow showed elevated concentrations at the downstream City of Cashmere site (Cotlets Way bridge) and then attenuation downstream, suggesting no new sources. We also sampled biofilms from Mission Creek in Cashmere and found that concentrations were only slightly above background (6.5 pg/g OC). Samples were limited during the May sampling due to high-flow scouring of the river bed and preventing access.

During the September 2015 sampling, the upstream site near the City of Cashmere (Goodwin bridge) was not above the background concentration. But the downstream site (Cotlets Way bridge) had concentrations an order of magnitude higher (Figure 15). Concentrations then increased downstream at the Old Monitor bridge site, then decreased further downstream at the Sleepy Hollow bridge site, and finally increased by an order of magnitude again at the furthest downstream site (under the Hwy 285 bridge).

Figure 15: PCB concentrations in biofilms normalized to organic carbon content.

Green = below ambient background. Red = above ambient background

Periphyton communities were identified under a microscope at Ecology and consisted mainly of diatoms with some filamentous green algae (Table D-7). The taxonomy relied on the text of Wehr and Sheath (2003), with more detailed classification of diatom taxa using Krammer and Lange-Bertalot (1986-1991). In general, communities were more diverse in the upper Wenatchee River. The dominant species in most samples was *Achnanthidium minutissimum*, a solitary stalked, benthic species. In the upper watershed there was a larger presence of *Didymosphenia geminata* and *Synedra* spp., both stalked benthic species. *Didymopshenia* is often referred to as a nuisance algae species because of the large stalked colonies that can clog small creeks and streams. We did not observe any significant growth of *Didymosphenia* in the field. In the lower watershed other stalked species were present, such as *Gomphonema* spp.

Macroinvertebrates and mountain whitefish diet

Benthic macroinvertebrates were enumerated in samples extracted from the stomachs of mountain whitefish. Samples were collected in May and September 2015 at locations near the confluence and near the USGS Peshastin site. In May, samples near the confluence contained almost exclusively caddisfly pupa (Trichoptera). Samples from the upstream site were far less abundant, but also contained almost exclusively caddisfly and mayfly (Plecoptera) larvae. The upstream stomach samples also contained coarse sand and gravel, indicative of the MWF feeding habit of picking larva from the river substrate. Samples collected during September 2015 near the confluence had a low abundance of invertebrates and consisted mainly of caddisfly larva. The stomach contents of the MWF from the upstream site during September 2015 consisted mainly of midge larva (Chironomidae), which are part of the same functional-feeding group as caddisflies.

Based on the stomach analysis, we targeted caddisfly and mayfly larva when picking samples at four locations in the Wenatchee River for PCB and DDT analysis. We targeted areas where biofilm contaminant concentrations were high and one background location (near the USGS Peshastin gaging station). All samples were analyzed for PCBs and one was analyzed for DDT. Similar to the biofilm results, we found that the site in Cashmere (Cotlets Way bridge) had PCB concentrations an order of magnitude higher (66.0 ng/g) than the upstream background site (1.1 ng/g). Concentrations then decreased at the downstream site at Old Monitor Bridge, and then increased by an order of magnitude near the Hwy 285 Bridge (Figure 16).

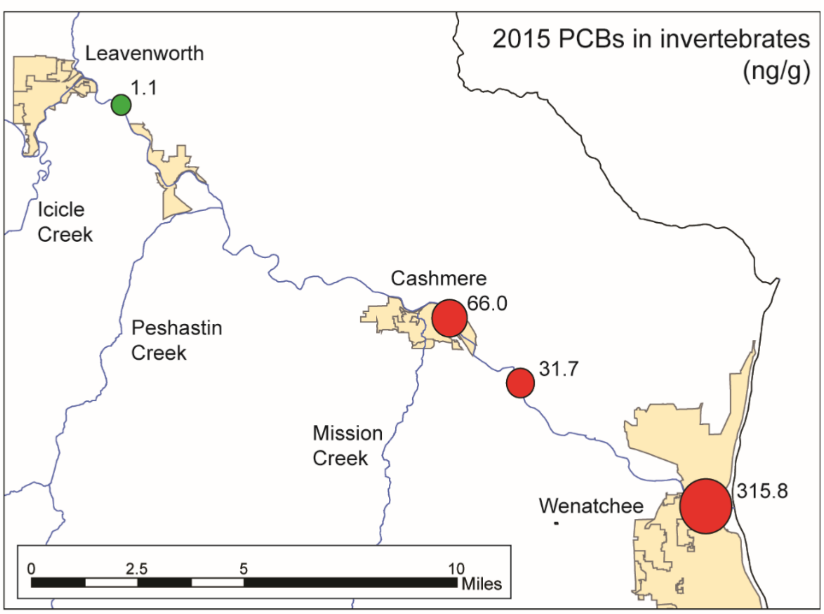


Figure 16: PCB concentrations in macroinvertebrates.

Stable isotopes and trophic position

For all of the biotic matrices we analyzed the N and C isotopic composition and elemental abundance (concentration) of the tissues. There are two reasons to assess these parameters: (1) to determine if there is an isotopic gradient downstream, which reflects varying nutrient sources, which could be used to infer where the MWF are feeding, and (2) to establish and confirm the trophic position of the organisms of interest in the Wenatchee food web (Post, 2002).

All the stable isotope data for the biotic matrices can be found in Tables D-6, D-8, and D-9. To assess changes in nutrient sources, we focus on the $\delta^{15}N$ of the biofilm samples (Figure 17). The $\delta^{15}N$ of biofilm has been shown to accurately reflect the $\delta^{15}N$ of the primary source of nitrogen (Pastor et al., 2013). There is a clear gradient from the upper to the lower Wenatchee, where the upper sample sites have $\delta^{15}N$ ratios (-0.9 – 1.4 ‰) that are depleted (lower) relative to the lower sample sites (5.5 – 6.2 ‰). The enrichment of the lower Wenatchee sample sites is likely a result of inorganic nitrogen (nitrate; NO_3 and ammonium; NH_4) inputs from fertilized lands and wastewater treatment plants located in Leavenworth, Peshastin, and Cashmere (Leavitt et al., 2006; Bunting et al., 2007).

When the isotopic data of both C and N is displayed as a biplot, the general structure of the Wenatchee food web can be deciphered (Figure 17). As shown in Figure 17, there is a clear grouping of organisms by location in the river. Furthermore, we would expect that with each trophic level there is an approximate 3.4 ‰ enrichment in $\delta^{15}N$ which is based on an organism's excretion of the lighter isotope (^{14}N) and retention of the ^{15}N of its diet (Post, 2002). In Figure 17, we can see that in the lower Wenatchee there is an approximate 3.4 ‰ enrichment from biofilm to invertebrate. The MWF show more variability in their isotopic composition−a function of the location of feeding and migration of the fish−but generally show a median 3.4 ‰ enrichment. It appears that each of the fish sampled in this study from the lower Wenatchee reside and feed in the lower Wenatchee, based on their isotopic composition compared with the invertebrate prey. If there was a migration of MWF between the upper and lower Wenatchee, the $\delta^{15}N$ of the MWF tissue would be lower (depleted).

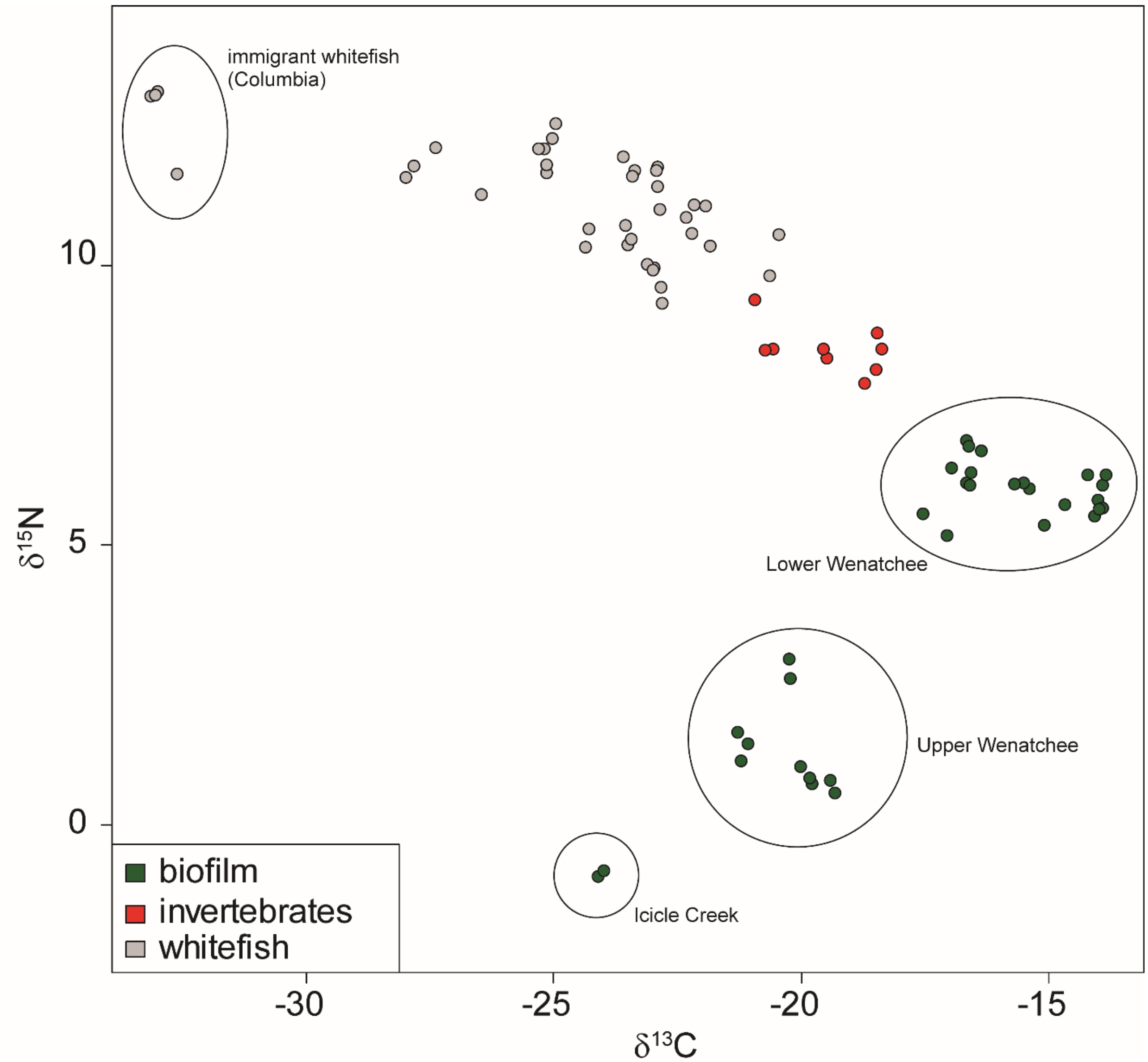


Figure 17: Stable isotope biplot for biofilms, invertebrates, and mountain whitefish tissues.

River Bed Survey

Transformers

One of the high priority potential PCB sources to the Wenatchee River was the possible presence of a transformer in the river bed near the City of Cashmere. In September 2014, we surveyed the river in the vicinity of where a Washington State Fisheries and Wildlife biologist had observed what appeared to be a transformer. We were able to locate an intact General Electric transformer, which was subsequently removed by Ecology, Chelan Co DNR, and Chelan PUD (Figure 18). The transformer contained a coarse-grain sand and some pieces of paper. The contents were analyzed by Chelan PUD using EPA method 8082, and showed no detections of PCBs.

Figure 18: Removal of intact transformer from the Wenatchee River near Aplets Way Bridge in Cashmere.

Photo taken by Tom Mackie, Ecology

This transformer was similar to a previous one located by the Chelan PUD and removed from the river in February 2010. Analytical results from the 2010 transformer showed the presence of 1.35 ppm of Aroclor 1260 in a sample of paper and no detections of PCBs in the sand/soil inside the transformer.

In September, 2015 Ecology completed a snorkel survey of the section of river near Cashmere where the previous transformers were located. We found an additional three transformers (Figure 19), all of them eroded and hollowed out.

The origin of the transformers is suspected to be an old City of Cashmere storage yard located adjacent to the Mission Creek confluence with the Wenatchee River. Anecdotal evidence suggests this yard was washed out during high flows in the mid-1990s, carrying with it debris that was on the site including old transformers. The number of transformers stored on the site is not known.

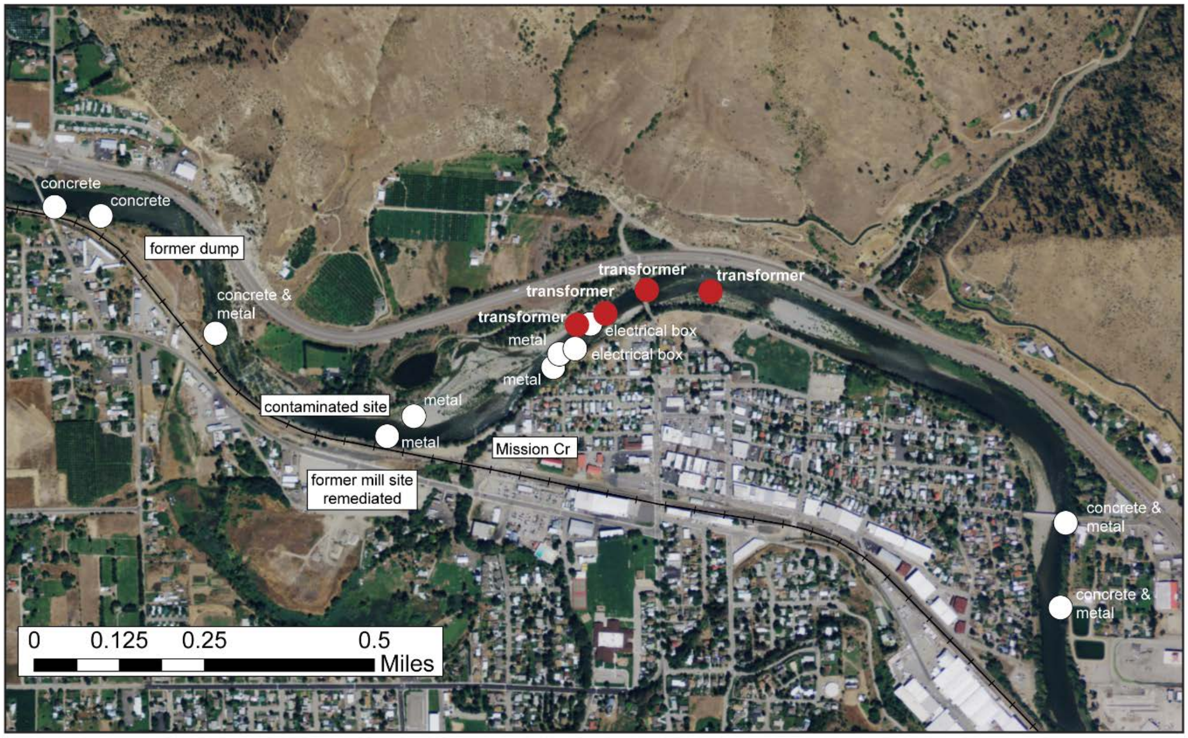


Figure 19: Map detailing the locations of the transformers (red dots) and other metal and concrete debris (white dots).

Courtesy Pete Cruikshank, Chelan Co DNR.

The extent of the map covers the section of river suspected of containing a PCB source, from Goodwin Bridge (left) to Cotlets Way Bridge (right).

Sediment

We took a single composite sediment sample from the backwater area at the confluence of the Wenatchee River and Columbia River. This is the only area of the lower Wenatchee River with any significant accumulation of fine sediment. At this sample site there is a significant exchange of water between the two rivers, due to upstream and downstream dams on the Columbia. At times Columbia River water will flow up the Wenatchee River to approximately river mile 1.5 (Carroll et al., 2006). Sediments consisted of fine grain sands and silts with 1.6 % organic carbon. The sediment contained 0.9 ng/g of t-PCBs and 8.4 ng/g t-DDT. These results are 2-3 orders of magnitude below the freshwater sediment management standards (WAC 173-204).

Discussion

PCB Sources

Ecology was able to undertake a comprehensive survey of potential PCB sources in the Wenatchee River. The upper Wenatchee basin contributes PCBs at low concentrations which are likely derived from atmospheric sources. There is very little change in concentrations from headwater tributaries down through the Cities of Leavenworth, Peshastin, and Dryden. We can therefore eliminate some of the potential sources (Table A- 1) including: the Leavenworth National Fish Hatchery, historic rail activities in Leavenworth, the former Great Northern Railway powerhouse upstream of Leavenworth in Tumwater Canyon, and the former dump site in Dryden.

The first significant increase in PCB concentrations occurs somewhere between the Goodwin Bridge and Cotlets Way Bridge in the City of Cashmere, a reach of approximately 2 river miles. This reach encompasses the locations of the five transformers found in the river, none of which contained significant PCB concentrations. While it is possible that additional transformers are buried in the river, the ones that have been discovered did appear to be decommissioned and filled with sand. Possible sources in this reach of the river include unknown contaminated sites, the Mission Creek basin, and stormwater.

Based on biofilm PCB concentrations, there is greater accumulation of PCBs occurring during the low-flow period. This suggests that stormwater would be an unlikely source to explain the observed increase in PCB concentrations. However, a more extensive survey during the high flow period is warranted to confirm whether stormwater is a significant source. Based on the findings from the current study, unknown contaminated sites and contaminated groundwater are the highest priority as a possible source in this reach of the Wenatchee River.

The second significant increase in PCB concentrations occurs somewhere between river mile 1.1 and 1.8, within the city limits of Wenatchee. Concentrations in all of the media sampled (water, biofilm and invertebrates) increase an order of magnitude within this reach of the river. The only hydrologic input in this reach is the Highline irrigation; however, it's difficult to hypothesize such a significant increase in PCBs from a small irrigation return. Again, it appears that an unknown contaminated site may be the source of the PCBs in this reach. Given that our measurements of PCBs in the confluence area of the Wenatchee with the Columbia are lower than upstream, it does not appear that the Columbia River water is leading to an increase in PCB concentrations at the downstream Wenatchee River sample sites.

The congener distribution of PCBs bound to the tissues of the biofilm is similar to the distributions of the dissolved phase PCBs in the water. When we compare the distributions of the PCB congeners from our SPMD samples to the known Aroclor congener distributions (Rushneck et al., 2004; Rodenburg et al., 2015), there are clearly two very different PCB sources. The multivariate analysis shown in Figure 20, describes the similarities of the samples to the Aroclor mixtures where the closer a sample is to the Aroclor on the plot the more similar it is. The first source near the City of Cashmere resembles Aroclor 1254, while the downstream source is composed of lighter PCB congeners and resembles Aroclor 1242/1248. In addition, the same spatial trends are apparent in both 2014 and 2015 samples.

The same multivariate analysis for the biofilm samples also shows lighter congeners and Aroclor 1248 at the most downstream site near the confluence (45WR01.1). There is less separation among the sites based on the PCB congener distributions of biofilms (Figure 20). There does appear to be more of an influence of Aroclor 1254 on the downstream biofilm sites which could also reflect some preferential binding of the heavier congeners. What is also evident from Figure 20 is that the distributions do not appear to change from high-flow to low-flow periods, suggesting a similar source during both periods.

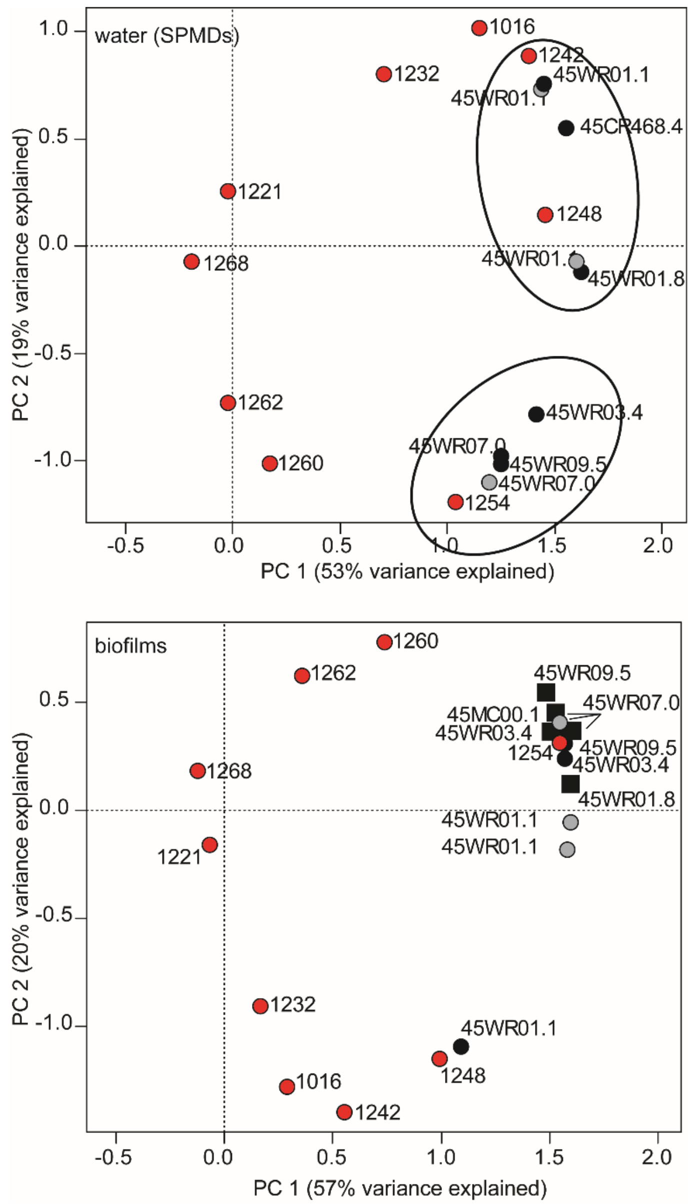


Figure 20: Principal components analysis of the PCB congener distributions in SPMDs (upper) and periphyton (lower) relative to Aroclor congener profiles.

Aroclors are the red dots; 2014 samples are in grey; 2015 samples are in black;
May samples are squares; September samples are circles.

Previous sampling of MWF and largescale sucker (*Catostomus macrocheilus*) tissues by Era-Miller (2004) found that fish caught in the Leavenworth area had only Aroclors 1254 and 1260, while fish from near the confluence with the Columbia also contained Aroclor 1248 and 1242. This finding is compatible with the two distinct PCB sources we see in both the water and biofilm samples. Further sampling using biofilm and SPMDs in the locations of the two potential sources should narrow in on a more local source.

In summary, there appears to be two chemically distinct PCB sources in the lower Wenatchee River, one near the City of Cashmere and the second near the City of Wenatchee. Further characterization of the stormwater inputs from these cities may be justified. However, given the data collected during both high and low-flow periods, stormwater should be considered a lower priority. The highest priority sources of PCBs in these locations are unknown contaminated sites and contaminated groundwater.

DDT Sources

We were able to survey the Wenatchee River basin for DDT in surface waters, including the upper Wenatchee basin. The initial survey in 2014 showed that major contributions of DDT to the Wenatchee River are confined to the section of river from Leavenworth downstream. During follow-up surveys of the mainstem, tributaries, and three irrigation returns we found elevated concentrations in Chumstick and Mission Creeks and the irrigation returns.

Previous work in the Mission Creek sub-basin has described the flux of DDT in this basin (Serdar and Era-Miller, 2004). This study found that the soils of the lower Mission Creek basin contained considerable amounts of DDT and ultimately were the upland source for Mission Creek. The movement of contaminated soil into the creeks is through surface runoff and wind. The concentrations of DDT in bed sediments of Yaksum Creek, a tributary to Mission Creek, were found to contain and be most representative of the DDT concentrations in orchard soils. Similar mechanisms for DDT movement into Chumstick Creek are suspected. The Chumstick Creek basin contains orchard lands, both current and historical.

The sampling devices used to sample water during this study enable us to only *estimate* water concentrations and therefore they cannot be considered in a regulatory context. Previous results from the Mission Creek basin found concentrations in Mission Creek of 2.4 and 3.2 ng/L (Serdar and Era-Miller, 2004), compared with an estimated 5.4 ng/L measured during this study. Concentrations in Brender Creek during the previous survey were 20 and 31 ng/L. A spillway sampled during the 2004 study from the Peshastin canal had a concentration of 3.2 ng/L, compared with an estimated 10.4 ng/L being discharged to Brender Creek from the Peshastin irrigation return in the current study. Overall, it appears that the concentrations of DDT in the Mission Creek sub-basin are on the same order of magnitude as previous sampling in 2003. Furthermore, the composition of the t-DDT is similar to the previous sampling, where 4,4'-DDE is the dominant analogue.

Brender and Mission Creek have been monitored for a large suite of pesticides since 2007 during the period of March through August, by Ecology (Sargeant et al., 2013) and now by the Washington State Department of Agriculture (Bischoff, pers. comm.). The sample site on Brender Creek is downstream of the sample sites discussed previously. In May 2015 grab samples for t-DDT ranged from 15 to 53 ng/L in Brender Creek. Since 2010 the detection frequency of 4,4'-DDE (the most commonly detected DDT analogue) has been decreasing, going from a maximum of ~90% in 2012-13 down to 30% in 2014 and 2015. The Mission Creek site is upstream of the Yaksum Creek input and has not had detectable concentrations of DDT over the period of sampling.

The results from the current study show that despite irrigation canals in the Wenatchee basin being almost entirely concrete-lined, there is DDT getting into these systems. The sampling during this study should be viewed as preliminary and it is not possible to say where in the irrigation system the contaminated soils or sediments are coming from. There are two main diversion points in the lower Wenatchee River basin, one from Icicle Creek at mile 5.8 and the second from the Wenatchee River near the Peshastin Creek input. Both these diversion points were assessed for DDT concentrations. The Icicle Creek diversion supplies water to the southern side of the Wenatchee River basin, while the Peshastin diversion supplies water to the northern part of the basin. Further work may be justified to survey the inputs from irrigation returns, however the relative load (concentration x discharge) is much less than from the tributaries (see *Contaminant Loading* section).

The most downstream site sampled near the confluence of the Wenatchee and the Columbia River showed little difference in DDT concentrations when compared to the upstream site at Old Monitor Bridge during the low-flow 2015 survey (Figure 11). However, it had concentrations an order of magnitude higher during the low-flow 2014 survey. We know there is significant influence of Columbia River water on the two most downstream sites (45CR468.4 and 45WR01.1) (Carroll et al., 2006). We also know that sections of the Columbia River upstream of the Wenatchee are contaminated with DDT (Seiders, 2015). It appears that Columbia River water influenced the downstream site during the 2014 low-flow survey. The 2015 low-flow survey did not appear to be influenced by Columbia River water, likely because of the increase in flow due to September storms which would increase tributary inputs. Similarly the results from the high-flow survey show little influence of the Columbia River water. These results suggest that the biota in this area of the confluence with the Columbia may be influenced by contaminated upstream Columbia River water during low-flow periods.

The DDT concentrations are greatest during higher flows. However, there are elevated concentrations during the lower flows, which is indicative of baseflow and low suspended solids conditions. This finding complements previous results that showed up to 25% of the DDT in Mission Creek and up to 80% in Yaksum Creek can be in the dissolved phase (Serdar and Era-Miller, 2004). Similar to previous studies in the Mission Creek basin, we did not find a strong relationship between total suspended solids (TSS) and t-DDT in the tributaries or mainstem.

In summary, the greatest inputs of DDT to the Wenatchee River occurred during the high-flow sampling events, predominately from the Chumstick and Mission Creek sub-basins. Concentrations measured in the Mission Creek basin during high-flow periods have not decreased substantially since the early 2000s. However, Department of Agriculture sampling has shown that overall detection of DDT compounds measured throughout the spring/summer has decreased in recent years.

Contaminant Loading

PCBs

We were only able to calculate PCB loads during the low-flow periods of 2014 and 2015 (Figure 21). During the 2014 sampling the PCB load remained fairly low until the Old Monitor Bridge site (downstream of Cashmere) when the load increased by an order of magnitude. The loads in 2015 were about half the 2014 loads, due to reduced flows. The concentrations in the water at the Old Monitor Bridge site were very close between 2014 (343.3 pg/L) and 2015 (313.0 pg/L).

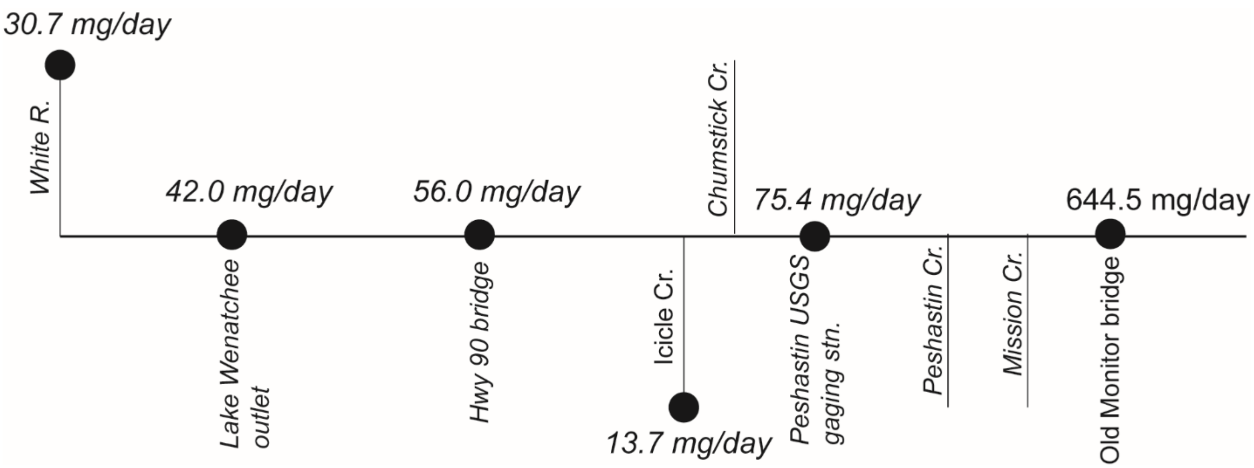


Figure 21: PCB loads for the Wenatchee River in September 2014.

It is likely that the PCB loads are higher during the high-flow periods because of the substantially greater flow. Based on the concentrations of PCBs in the biofilm samples collected at high-flow, the water concentrations are likely lower. When considering the concentrations versus loads of bioaccumulative chemicals, it is worth considering that it is the accumulation of PCBs and DDT on the biofilm that is the entry into the food web. Therefore, despite the load being lower during low-flow periods, we have shown that there is greater accumulation of chemicals on the biofilm during low-flow and therefore greater transfer of the chemicals up the food web.

DDT

The largest DDT loads in the Wenatchee River basin were measured in the lower Wenatchee (Figure 22). Similar to the results of DDT concentrations, there is an increase in DDT load of an order of magnitude following the input of Chumstick Creek and an additional increase in load downstream of Mission Creek.

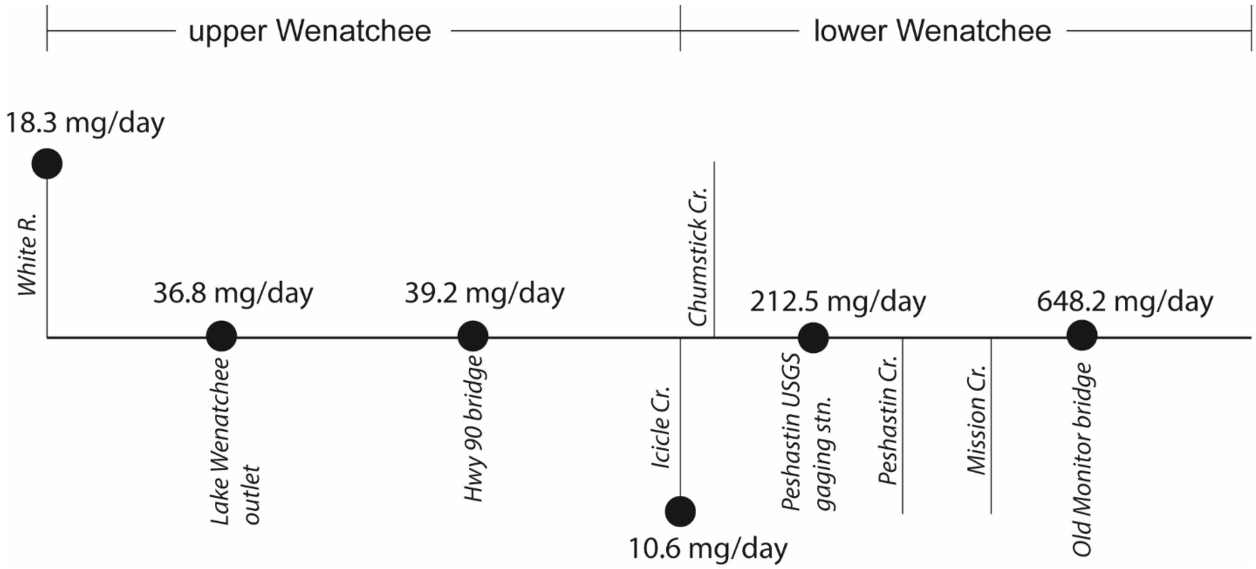


Figure 22: DDT loads for the Wenatchee River basin in September 2014.
Calculated from estimated DDT concentrations sampled using SPMDs.

The more detailed survey of tributaries and irrigation returns showed that the most significant loads of DDT to the Wenatchee River occur during the high-flow periods from Chumstick and Mission Creeks (Table D-10). The load measured at the USGS Peshastin gaging station is largely accounted for by the Chumstick Creek load, with the remainder likely attributable to Icicle Creek and the upstream Wenatchee River load (Figure 23). The increase in DDT load measured at Old Monitor Bridge in the mainstem Wenatchee River cannot be accounted for entirely by Mission Creek. Also, the upstream load, which combined with the Peshastin Creek load, only accounts for approximately 30% of the measured load at Old Monitor. This suggests there is an additional DDT source between the USGS Peshastin gaging station and Old Monitor Bridge. However, there is no significant unsampled tributary in this reach. Verification of a possible unknown source should be undertaken.

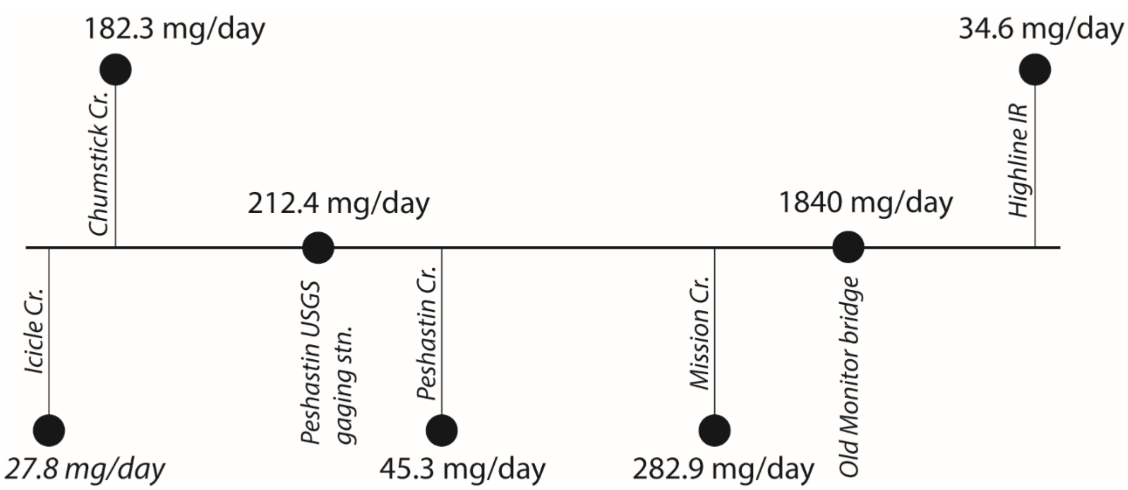


Figure 23: DDT loads for the lower Wenatchee River basin in May 2015.
Calculated from estimated DDT concentrations sampled using C.L.A.M. devices.

The calculated DDT loads also show that the irrigation returns are not large sources of DDT to the Wenatchee River. There are no estimates of flow from the Peshastin-Icicle Irrigation District, but visual comparison to the Highline canal suggests the flow is lower. The Peshastin Irrigation return is accounted for in the Mission Creek load. Compared to results of high-flow periods, results during the low-flow period show that the load from tributaries is 1 to 2 orders of magnitude lower and the load from the irrigation returns is about half (Table D-10). Previous estimates of loads during high-flow from Mission Creek ranged from 36 to 191 mg/day during sampling in 2003 (Serdar and Era-Miller, 2004) and from 250-660 mg/day during the 2000 sampling (Serdar and Era-Miller, 2002). Our sample site represents the combination of Brender, Mission, and Yaksum Creeks and, after combining previous loads to make comparisons with historical loads during the high-flow period, it appears there has been little change in DDT load from the Mission Creek basin since 2003 (Figure 24). However, there is currently a lower DDT load than in April 2000.

The load during low-flow months (September-October) is considerably lower (3.3 mg/day in 2015) compared with the sampling in 2000 (386 mg/day in September and 29 mg/day in October). Overall, it appears that there has been some reduction in DDT loading since 2000 in the Mission Creek basin.

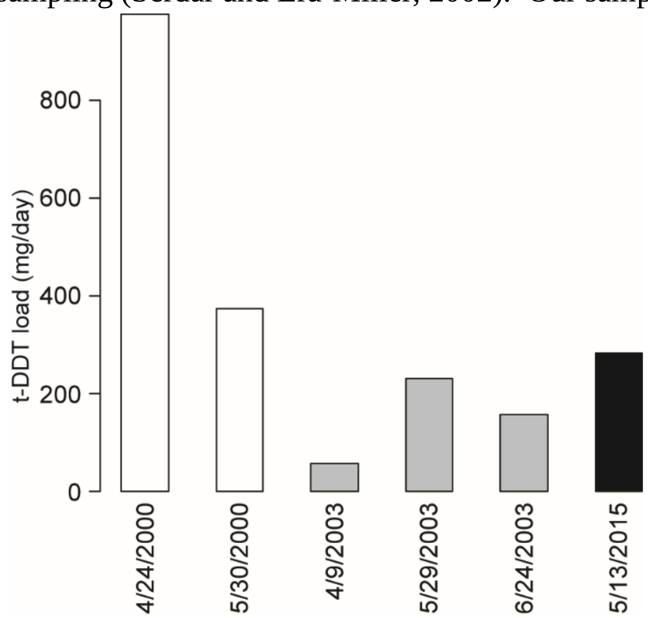
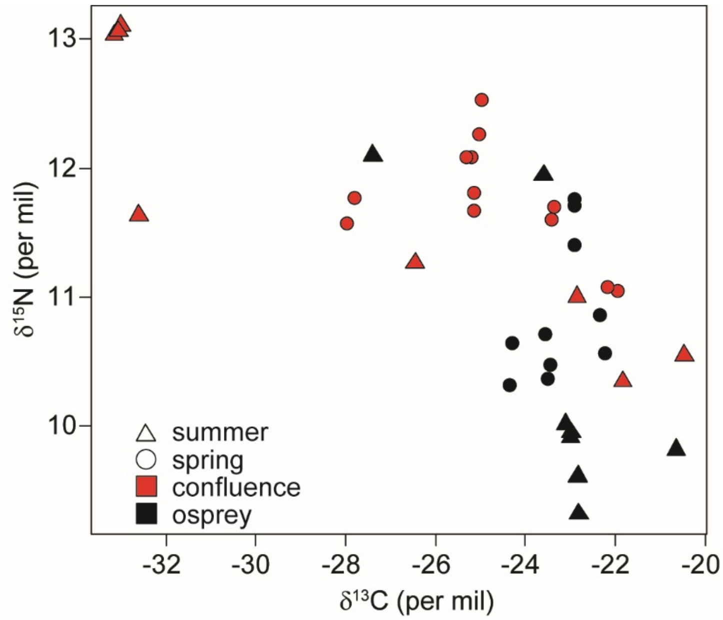


Figure 24: Comparison of DDT loads in Mission Creek basin since 2000.

Wenatchee Food Web

This source assessment was initiated because of the elevated concentrations of PCBs and DDT in mountain whitefish. It is therefore important to understand the food web of the Wenatchee River and where the MWF are accumulating these contaminants. During our 2015 sampling we collected a number of MWF and extracted the contents of their stomachs to confirm diet. The MWF in the Wenatchee appear to have a very selective diet, consisting of caddisfly and mayfly larvae, and occasionally midge larvae. This finding is consistent with other studies on the feeding habits of MWF (Northcote and Ennis, 1994; Thompson and Davies, 1976). The collections of MWF took place during the spring and late summer of 2015. In general the MWF were younger in summer collections and the fish collected near the confluence were younger than those collected upriver near the Osprey Rafting Company site (river mile 21) (Table D-9).

The isotopic data we collected on the Wenatchee food web can offer some information on the life history of the MWF collected. As described in the *Results* section, there is a gradient of $\delta^{15}N$ in the biofilm that reflects changes in nitrogen sources downstream, where the $\delta^{15}N$ becomes



higher (more enriched) downstream. The $\delta^{15}N$ of the MWF sampled downstream near the confluence tend to be heavier (higher) than those sampled upstream near river mile 21 (Figure 25). This trend suggests that the fish appear to be feeding in the vicinity of the sample sites. This conclusion is based on the fact that the $\delta^{15}N$ of biofilm tissues is lower in the Icicle Creek – Leavenworth area (Osprey MWF) than in the confluence area. The PCB and DDT concentrations of the fish tissue samples will be analyzed in the near future under a different project (Seiders, 2015).

Figure 25: Stable isotope biplot of mountain whitefish tissues collected from the lower Wenatchee River.

The functional feeding habits of caddisfly and mayfly larvae are collector-filterers. The caddisfly typically filters material from the overlying water by positioning their legs in front of their head outside their casing. In addition, they graze biofilm and epilithic (growing on rocks) algae such as diatoms (Hauer and Stanford, 1985).

The largescale suckers are also an important organism in the Wenatchee food web, as they are benthic feeders and occupy a lower trophic level than MWF. The diet of Columbia River suckers consists mainly of periphyton and some invertebrates (midge and caddis fly larvae) (Dauble, 1986). Due to budgetary constraints we were unable to sample suckers and confirm their diet and trophic position in the food web. It is likely they occupy a trophic level between the caddisfly larvae and the MWF.

Periphyton communities were more diverse in the upper Wenatchee River. It is unlikely that periphyton diversity impacts the accumulation of contaminants. Biofilm had greater lipid content during the low-flow summer period, which may influence the accumulation of PCBs and DDT.

Bioaccumulation of PCBs

Bioaccumulation of PCBs can be described as the uptake from water (bioconcentration) and diet of an organism. In the contaminated portion of the river (downstream of Goodwin Bridge in Cashmere) the bioconcentration factors (BCFs) between water and biofilm ranged from 721 to 2413 L/kg. The lowest BCFs are present near the confluence where water concentrations are the highest. The bioaccumulation factors (BAFs) for the invertebrate samples were found to range from 1.0 to 2.0 x 10^5 L/kg. PCBs in fish tissue were not yet analyzed at the time of writing and therefore BAFs for the fish could not be calculated.

Spatially, it appears that greater bioaccumulation of PCBs in the Wenatchee food web is occurring downstream of Cashmere. This is contradictory to the 303(d) listing of Icicle Creek and the Wenatchee River near Peshastin based on fish tissue concentrations of PCBs, as presented in the work of Era-Miller (2004) and Seiders et al. (2007). It appears that contaminated fish caught in the Leavenworth area are migrating and feeding downstream. Therefore, listing Icicle Creek and the Leavenworth reaches of the Wenatchee River for PCBs under the 303(d) list seems inappropriate.

Based on the food web described in the previous section, we assembled a preliminary food web model to describe and predict the accumulation of PCBs in the lower Wenatchee food web. We used a model based on that of Arnot and Gobas (2004) which has been employed in Washington State freshwaters in the Spokane River (Serdar et al. 2011) and Lake Washington (DeGasperi et al., 2014). This model was initially adapted by Pelletier and Mohamedali (2009) for the Puget Sound. The model parameters used are described in Appendix E. Unfortunately, no comprehensive data set was available for PCBs in mountain whitefish from the lower Wenatchee to properly calibrate the model. Further analysis of fish collected during this study will contribute to future calibration of the model (Seiders, 2015).

We were able to rely on site-specific data in most cases; however, our data set proved somewhat limited both spatially and temporally. For instance, the model did a poor job at predicting biofilm concentrations, despite the proven relationship between dissolved PCB concentrations in water and biofilm that we found in this study. This may be due to a bias in our samples toward the low-flow period. Model bias was evaluated as per Arnot and Gobas (2004), based on accuracy of predicting each congener. The overall accuracy of the invertebrate predictions was very good (Table 2); however, the model bias was somewhat high because many of the lighter congeners that make up less of the PCB mass were over-predicted.

Table 2: Results of the preliminary PCB bioaccumulation model.

Organism	Observed concentrations (ng/g)	Predicted concentrations (ng/g)	Model Bias[†]
Biofilm	0.24	5.46	16.6
Caddisfly	45.8	44.5	1.57
Mayfly	45.8	46.1	2.15
Mountain whitefish	902[ǂ]	191	0.5

[†] Model bias is an indication of the under- or over-prediction by the model (Arnot and Gobas, 2004; equation 24). A bias of 1.0 represents an exact match between observed and predicted concentrations.

[ǂ] Data from Seiders et al. (2007) from one sample near Leavenworth

Overall, the bioaccumulation model produced in this study needs further support from site-specific data. A follow-up study should be conducted to generate data for both MWF and largescale suckers and further refine our understanding of biofilm concentrations throughout the year. Ultimately, the goal of compiling an accurate bioaccumulation model would be to predict the necessary water and biofilm concentrations needed for fish tissue concentrations to be below the Department of Health’s fish consumption threshold of 46 µg/Kg t-PCBs. If concentrations are below the threshold, the consumption advisory could be withdrawn. Also an accurate model could predict the necessary concentrations for fish tissue to be below the FTEC water quality assessment level for the protection of human health (5.3 µg/Kg t-PCBs).

Conclusions

Results of this 2014-2015 source assessment study support the following conclusions.

PCBs

- A strong statistically significant relationship was found between dissolved PCB concentrations in water estimated from SPMDs and measured PCB concentrations in biofilm.
- PCB concentrations and congener patterns in water and biofilms suggest two distinct PCB sources. One near the City of Cashmere and the second near the City of Wenatchee. Unknown contaminated sites are the likely sources.
- PCB concentrations in macroinvertebrates, representing the diet of mountain whitefish, had a similar spatial trend to estimated water concentrations and measured biofilm concentrations.
- A total of five transformers have been located in the Wenatchee River near a former City of Cashmere storage yard. Two were intact and removed. No appreciable concentrations of PCBs were measured on the paper and soil/sand contents of the recovered transformers.
- Higher concentrations of PCBs were measured in the biofilm during the low-flow period of the year.

DDT

- The greatest inputs of DDT to the Wenatchee River are occurring during high-flow, predominately from the Chumstick and Mission Creek sub-basins.
- Concentrations measured in the Mission Creek basin during high-flow periods have not decreased substantially since the early 2000s. However, sampling by Ecology and the Department of Agriculture has shown that overall detection of DDT compounds measured throughout the spring/summer has decreased in recent years.
- The calculation of DDT loads shows that irrigation returns are not large sources of DDT to the Wenatchee River.
- There appears to be an unknown source of DDT between the USGS Peshastin gaging station and Old Monitor Bridge. There is no significant unsampled tributary in this reach.
- Water from the Columbia River appears to influence the concentrations of DDT in the lower Wenatchee near the Hwy 285 Bridge.
- Measurable concentrations of DDT were found in the sediments of the backwater channels near the confluence with the Columbia. Sediments did not exceed the state sediment management standards.

Wenatchee River Food Web and Bioaccumulation

- Mountain whitefish of the Wenatchee River appear to have a very selective diet, consisting of caddisfly and mayfly larvae, and occasionally midge larvae.
- Modeling the Wenatchee food web using stable isotopes showed that mountain whitefish sampled during this study from the lower Wenatchee appear to reside and feed in the lower Wenatchee, and they do not migrate to the Upper Wenatchee River to feed. Mountain whitefish do appear to migrate within the lower Wenatchee.
- It appears that contaminated fish caught in the lower Wenatchee, Leavenworth area, during previous studies were migrating and feeding downstream. Therefore, listing Icicle Creek and the Leavenworth reaches of the Wenatchee River for PCBs under the 303(d) list seems inappropriate.
- A preliminary food web model for PCBs in the lower Wenatchee River food web was able to predict invertebrate PCB concentrations well. No comprehensive data set was available for PCBs in mountain whitefish from the lower Wenatchee to properly calibrate the model.

Recommendations

The findings of this initial source assessment provide some clear follow-up actions and opportunities for further investigation. The DDT and PCB sources are quite different and follow-up actions should be designed with this in mind.

PCBs

1. We have found two source areas of PCBs to the Wenatchee River. Using the same techniques as this study, further delineation within the possible source areas should be carried out. This would include improved characterization of PCB loads during high- and low-flow conditions.
2. While it appears that stormwater may not be a dominant source of PCBs in the Wenatchee River, it is important to verify this. Other river basins in Washington with urban areas have measured large contributions of PCBs in stormwater. Therefore the inputs of PCBs to the Wenatchee River from stormwater and wastewater in the cities of Cashmere and Wenatchee should be investigated.
3. Discuss the current 303(d) category 5 listing for Icicle Creek and the Leavenworth/Peshastin sections of the Wenatchee River. This study has shown that while fish collected from these reaches during previous studies exceed the FTEC water quality assessment level for the protection of human health for PCBs, the actual impairment of the river is approximately 10 river miles downstream.

DDT

1. It appears that there is an unknown contribution of DDT to the Wenatchee River, despite all of the major tributaries in the lower Wenatchee being sampled. Verification of the unaccounted DDT should be the first step in the investigation of the unknown DDT contribution.
2. DDT loads from the Chumstick Creek watershed were significant. The Washington State Department of Agriculture (WSDA) has an ongoing program monitoring pesticides in the Mission Creek watershed. It would be beneficial to both Ecology and WSDA to expand the monitoring of DDT within the Mission and Chumstick Creek basins and initiate the discussion of a strategy for the reduction of DDT from these watersheds.

Bioaccumulation

Continuing to understand the transfer of PCBs and DDT within the food web of the Wenatchee River will provide site-specific benchmarks and bioaccumulation factors. These will be important in monitoring the effectiveness of any remedial actions and in formulating a long-term source control plan for toxics in the Wenatchee River basin. In follow-up to this study, Ecology should:

1. Produce a complete bioaccumulation model for PCBs and DDT in the lower Wenatchee. A bioaccumulation model will allow for the prediction of water and biofilm concentrations

necessary for fish tissues to be below the Department of Health advisory targets for PCBs (46 µg/Kg) and the FTEC water quality assessment level for the protection of human health for PCBs (5.3 µg/Kg) and DDT (32 µg/Kg).

2. Confirmation of the life history and resident range of mountain whitefish should be investigated through a collaborative fish tracking study with Washington Department of Fish and Wildlife (WDFW). It is important to understand whether MWF migrate between the upper and lower Wenatchee River and how long MWF in the lower Wenatchee spend in the contaminated reach of the river. Previous work by WDFW in the Wenatchee River basin has already established the necessary infrastructure for such a study.

References

Personal Communications

Matthew Bischoff, Washington State Department of Agriculture, March 17, 2016.

David A. Alvarez, US Geological Survey, December 5, 2014.

References Cited in Text

Alvarez, D.A., 2010. Guidelines for the use of the semipermeable membrane device (SPMD) and the polar organic chemical integrative sampler (POCIS) in environmental monitoring studies: U.S. Geological Survey, Techniques and Methods 1–D4, 28 p.

Arnot, J. and F. Gobas, 2004. A food web bioaccumulation model for organic chemicals in aquatic ecosystems. Environmental Toxicology and Chemistry. 23: 2343-2355.

Arnot, J. and F. Gobas, 2006. A review of bioconcentration factor (BCF) and bioaccumulation factor (BAF) assessments for organic chemicals in aquatic organisms. Environmental Reviews. 14: 257-297.

Blakley, N., 2007. Standard Operating Procedure for Obtaining Freshwater Sediment Samples. Washington State Department of Ecology, Olympia, WA. SOP Number EAP040. www.ecy.wa.gov/programs/eap/quality.html

Bunting, L., P.R. Leavitt, C.E. Gibson, E.J. McGee, and V.A. Hall, 2007. Degradation of water quality in Lough Neagh, Northern Ireland, by diffuse nitrogen flux from a phosphorus-rich catchment. Limnology and Oceanography 52:354-369.

Callahan, M.A., M.W. Slimak, N.W. Gabel, I.P. May, C.F. Fowler, J.R. Freed, P. Jennings, R.L. Durfee, F.C. Whitmore, B. Maestri, W.R. Mabey, B.R. Holt, and C. Gould, 1979. Water-Related Environmental Fate of 129 Priority Pollutants, Volume 1: Introduction and Technical Background, Metals and Inorganics, Pesticides and PCBs. Office of Water and Waste Management, U.S. Environmental Protection Agency, Washington D.C. EPA-440/4-79-029a

Carroll, J., S. O'Neal, and S. Golding, 2006. Wenatchee River Basin Dissolved Oxygen, pH, and Phosphorus Total Maximum Daily Load Study. Washington State Dept. of Ecology. Olympia, WA. Publication No. 06-03-018. https://fortress.wa.gov/ecy/publications/summarypages/0603018.html.

Dauble, D.D., 1986. Life history and ecology of the largescale sucker (*Castostomus macrocheilus*) in the Columbia River. The American Midland Naturalist. 116: 356-367.

DeGasperi, C., J. Colton and C. Greyell, 2014. Development of Lake Washington PCB Fate and Bioaccumulation Models. Department of Natural Resources and Parks, Water and Land Resources Division, King County. 91 p.

Era-Miller, B., 2004. Verification of 303(d)-listed Sites in Northwest, Central, and Eastern Regions of Washington State. Washington State Dept. of Ecology. Olympia, WA. Publication No. 04-03-035. https://fortress.wa.gov/ecy/publications/summarypages/0403035.html.

Hauer, F.R. and Stanford, J.A., 1985. Ecology and coexistence of two species of Brachycentrus (Trichoptera) in a Rocky Mountain river. Canadian Journal of Zoology. 64: 1469-1474.

Hobbs, W., 2014. Quality Assurance Project Plan: Wenatchee River PCB and DDT Source Assessment. Washington State Dept. of Ecology. Olympia, WA. Publication No. 14-03-117. https://fortress.wa.gov/ecy/publications/summarypages/1403117.html

Hobbs, W., 2015. Addendum to Quality Assurance Project Plan: Wenatchee River PCB and DDT Source Assessment. Washington State Dept. of Ecology. Olympia, WA. Publication No. 15-03-107. https://fortress.wa.gov/ecy/publications/summarypages/1503107.html

Honrath, R., C. Sweet, and C. Plouff, 1997. Surface exchange and transport processes governing atmospheric PCB levels over Lake Superior. Environmental Science & Technology 31: 842-852.

Hopkins, B.S., D.K. Clark, M. Schlender, and M. Stinson, 1985. Basic Water Monitoring Program Fish Tissue and Sediment Sampling for 1984. Washington State Dept. of Ecology. Olympia, WA. Publication No. 85-7. https://fortress.wa.gov/ecy/publications/summarypages/857.html.

Huckins, J.N., J.D. Petty, and K. Booij, 2006. Monitors of organic chemicals in the environment: Semipermeable membrane devices. Springer, New York, USA. 223p.

Joy, J. 2006. Standard Operating Procedure for Manually Obtaining Surface Water Samples. Washington State Department of Ecology, Olympia, WA. SOP Number EAP015. www.ecy.wa.gov/programs/eap/quality.html

Krammer, K., and H. Lange-Bertalot (1986–1991), Bacillariophyceae, in Süsswasser Flora Von Mitteleuropa, Band 2/1-4, edited by H. Ettl et al., Gustav Fischer Verlag, Stuttgart, Germany, and New York.

Leavitt, P.R., C.S. Brock, C. Ebel, and A. Patione, 2006. Landscape-scale effects of urban nitrogen on a chain of freshwater lakes in central North America. Limnology and Oceanography 51:2262-2277.

MacKay, D. and S. Paterson, 1991. Evaluating the multimedia fate of organic chemicals: a level III fugacity model. Environmental Science & Technology, 25: 427-436.

MacKay, D., W.Y. Shui, and K.C. Ma, 1997. Illustrated handbook of physical-chemical properties and environmental fate for organic chemicals. Vol. 5: Pesticide chemicals. CRC Press, Boca Raton, FL.

McCarthy, K.A. and R.W. Gale, 1999. Investigation of the Distribution of Organochlorine and Polycyclic Aromatic Hydrocarbon Compounds in the Lower Columbia River Using Semipermeable Membrane Devices. U.S. Geological Survey, Portland, Oregon. Water Resources Investigations Report 99-4051.

Mathieu, N., S. Collyard, T. Mohamedali, 2013. Standard Operating Procedures for the Collection of Periphyton Samples for TMDL studies. Washington State Department of Ecology, Olympia, WA. SOP Number EAP085. www.ecy.wa.gov/programs/eap/quality.html

Morace, J.L., 2012. Reconnaissance of Contaminants in Selected Wastewater-Treatment-Plant Effluent and Stormwater Runoff Entering the Columbia River, Columbia River Basin, Washington and Oregon, 2008-2010. U.S. Geological Survey Scientific Investigations Report 2012-5068. 68 p.

Northcote, T.G. and G.L. Ennis, 1994. Mountain Whitefish Biology and Habitat Use in Relation to Compensation and Improvement Possibilities. Review in Fisheries Science. 2: 347-371.

Pastor, A., M. Peipoch, L. Cañas, E. Chappuis, M. Ribot, E. Gacia, J.L. Riera, E. Martí, and F. Sabater, 2013. Nitrogen stable isotopes in primary uptake compartments across stream differing in nutrient availability. Environmental Science & Technology. 47:10155-10162.

Pelletier, G., and T. Mohamedali, 2009. Control of Toxic Chemicals in Puget Sound Phase 2: Development of simple numerical models – The long-term fate and bioaccumulation of polychlorinated biphenyls in Puget Sound. Washington State Department of Ecology, Olympia, WA. Publication No. 09-03-015. www.ecy.wa.gov/biblio/0903015.html.

Post, D.M.,2002. Using stable isotopes to estimate trophic position: models, methods, and assumptions. Ecology. 83: 703-718.

Ridolfi Inc., 2011a. Wenatchee River Basin Pilot Study Results Report. Prepared for the Yakama Nation Fisheries, Resource Management Program 29 p.

Ridolfi Inc., 2011b. Wenatchee River Targeted Soil Sampling Results Report. Prepared for the Yakama Nation Fisheries, Resource Management Program. 27 p.

Rodenburg, L.A., D. Delistraty, and Q. Meng, 2015. Polychlorinated biphenyl congener patterns in fish near the Hanford Site (Washington State, USA). Environmental Science & Technology 49:2767-2775.

Rushneck, D. R.; Beliveau, A.; Fowler, B.; Hamilton, C.; Hoover, D.; Kaye, K.; Berg, M.; Smith, T.; Telliard, W. A.; Roman, H.; Ruder, E.; Ryan, L., 2004. Concentrations of dioxin-like PCB congeners in unweathered Aroclors by HRGC/HRMS using EPA Method 1668A. Chemosphere 54,79−87

Salamova, A., Pagano, J. J., Holsen, T. M., & Hites, R. A., 2013. Post-1990 Temporal Trends of PCBs and Organochlorine Pesticides in the Atmosphere and in Fish from Lakes Erie, Michigan, and Superior. Environmental Science & Technology, 47(16), 9109-9114.

Sandvik, P., 2009. Washington State Toxics Monitoring Program: Trends Monitoring for Chlorinated Pesticides, PCBs, and PBDEs in Washington Rivers and Lakes, 2007. Washington State Dept. of Ecology. Olympia, WA. Publication No. 09-03-013. https://fortress.wa.gov/ecy/publications/summarypages/0903013.html.

Sargeant, D., E. Newell, P. Anderson, and A. Cook, 2013. Surface Water Monitoring Program for Pesticide in Salmon-Bearing Streams, 2009-2011 Triennial Report. A Cooperative Study by the Washington State Departments of Ecology and Agriculture. Washington State Dept. of Ecology. Olympia, WA. Publication No. 13-03-002. https://fortress.wa.gov/ecy/publications/summarypages/1303002.html.

Seiders, K., 2015. Addendum 4 to Quality Assurance Project Plan: Freshwater Fish Contaminant Monitoring Program: 2015. Washington State Dept. of Ecology. Olympia, WA. Publication No. 15-03-126. https://fortress.wa.gov/ecy/publications/summarypages/1503126.html.

Seiders, K., C. Deligeannis, and P. Sandvik, 2007. Washington State Toxics Monitoring Program: Contaminants in Fish Tissue from Freshwater Environments in 2004 and 2005. Washington State Dept. of Ecology. Olympia, WA. Publication No. 07-03-024. https://fortress.wa.gov/ecy/publications/summarypages/0703024.html.

Seiders, K. and P. Sandvik, 2012. Standard Operating Procedure for Semi-Permeable Membrane Devices (SPMDs) Data Management and Data Reduction. Washington State Department of Ecology, Olympia, WA. SOP Number EAP079. www.ecy.wa.gov/programs/eap/quality.html

Seiders, K., C. Deligeannis, and M. Friese, 2012a. Washington State Toxics Monitoring Program: Freshwater Fish Tissue Component, 2013. Washington State Dept. of Ecology. Olympia, WA. Publication No. 12-03-023. https://fortress.wa.gov/ecy/publications/summarypages/1203023.html

Seiders, K., P. Sandvik, and A. Johnson, 2012b. Standard Operating Procedures for Conducting Studies using Semi-Permeable Membrane Devices (SPMDs). Washington State Department of Ecology, Olympia, WA. SOP Number EAP001. www.ecy.wa.gov/programs/eap/quality.html

Serdar, D. and B. Era-Miller, 2002. Pesticide Monitoring in the Mission Creek Basin, Chelan County. Washington State Dept. of Ecology. Olympia, WA. Publication No. 02-03-022. https://fortress.wa.gov/ecy/publications/summarypages/0203022.html

Serdar, D. and B. Era-Miller, 2004. DDT Contamination and Transport in the Lower Mission Creek Basin, Chelan County. Washington State Dept. of Ecology. Olympia, WA. Publication No. 04-03-043. https://fortress.wa.gov/ecy/publications/summarypages/0403043.html.

Sinkkonen, S. and J. Paasivirta, 2000. Degradation half-life times of PCDDs, PCDFs and PCBs for environmental fate modeling. Chemosphere. 40: 943-949.

Sloan, J. and N. Blakley, 2009. Baseline Characterization of Nine Proposed Freshwater Sediment Reference Sites, 2008. Washington State Dept. of Ecology. Olympia, WA. Publication No. 09-03-032. https://fortress.wa.gov/ecy/publications/summarypages/0903032.html.

Stange, K. and Swackhamer, D.L., 1994. Factors affecting phytoplankton species-specific differences in accumulation of 40 polychlorinated biphenyls (PCBs). Environmental Toxicology and Chemistry. 13:1849-1860.

Stevenson, R.J. and L. Bahls. “Periphyton Protocols” in Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling, 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Swackhamer, D.L. and Skoglund, R.S., 1993. Bioaccumulation of PCBs by algae: kinetics versus equilibrium. Environmental Toxicology and Chemistry. 12: 831-838.

Swanson, T. 2007. Standard Operating Procedures for Hydrolab DataSonde® and MiniSonde® Multiprobes. Washington State Department of Ecology, Olympia, WA. SOP Number EAP033. www.ecy.wa.gov/programs/eap/quality.html

WAC 173-201A. Water Quality Standards for Surface Waters in the State of Washington. Washington State Department of Ecology, Olympia, WA. www.ecy.wa.gov/laws-rules/ecywac.html.

WAC 173-204. Sediment Management Standards in the State of Washington. Washington State Department of Ecology, Olympia, WA. www.ecy.wa.gov/laws-rules/ecywac.html.

Wehr, J.D. and R.G. Sheath (Eds), 2003. Freshwater Algae of North America. Academic Press, San Diego, CA. 918 pp.

Xie, W. H., W.Y. Shiu, and D. MacKay, 1997. A review of the effect of salts on the solubility of organic compounds in seawater. Marine Environmental Research, 44: 429-444.

Appendix A. Potential sources

Table A-1: PCB sources, location, Phase 1 sampling approach, and rank of concern.

Source	Notes / Rationale	Sampling approach	Rank
Transformer in river bed	During a survey of the riverbed for steelhead spawning by Washington Department of Fish and Wildlife in April 2009, a suspected transformer was noted in the mid-channel downstream of Cashmere. Further investigation of the suspected transformer location is necessary at low flow.	Water and periphyton in the vicinity of the transformer location	High
Great Northern Railway (GNR) Powerhouse	A dam and powerhouse were constructed when the GNR ran up Tumwater Canyon, with 3 large turbines and 3 - 2000 kW generators. The powerhouse and dam remained in operation until 1956. Further clarification on the location and magnitude of GNR operations in Leavenworth could yield an additional potential PCB source.	Water and biofilm in the vicinity of the site	High
Leavenworth Fish Hatchery (LFH)	The LFH has conducted previous investigations into PCBs in paint on the rearing tanks (raceways), in the fish food, Chinook salmon fry and pre-smolts, and the sediments within Icicle Creek and an on-site retention pond. PCBs were detected on-site but not in the Icicle Creek sediments. Further investigation of the receiving environment seems warranted.	Water and biofilm in the vicinity of the site	High
POTWs on the Wenatchee River	POTWs and stormwater effluent have been observed to be a dominant source of PCBs in the Spokane River. There is not a large industrial presence in the towns along the Wenatchee River. Sources of PCBs in an urban environment are old transformers and capacitors, inks (e.g., paper recycling facilities), and sealants and caulking in buildings and piping.	Initial river survey of water. Possible follow-up of water at the point of discharge to the Wenatchee River	Medium
Stormwater discharging to the Wenatchee River			Medium
Contaminated Sites	Washington State Department of Ecology maintains the Integrated Site Information System (ISIS) which the Toxics Cleanup Program uses to prioritize and track the remediation of contaminated sites. Currently all but 2 sites in ISIS do not require further action. The remaining 2 sites are old, small landfills which do not appear to pose a significant risk.	Initial river survey of water	Low
Irrigation returns	PCBs are not a suspected contaminant in the application of pesticides or insecticides on agricultural land. However, the irrigation returns that drain these lands and discharge to the Wenatchee River can act as conduits for various pollutants that may be associated with historical practices, dumpsites, or atmospheric deposition.	Initial river survey of water	Low
Atmospheric deposition	Cold trapping or cold condensation of PCBs suggests that greater amounts of PCBs are deposited at higher elevations compared with the lower Wenatchee Valley. The PCBs deposited from atmospheric deposition are likely to also have a different congener pattern. It is more likely that the deposition of atmospheric PCBs emanating from the Puget Sound region takes place on the western side of the Cascades.	Initial river survey of water to test whether PCB congeners are indicative of atmospheric deposition	Low

Source	Notes / Rationale	Sampling approach	Rank
Returning salmon	Returning hatchery Chinook salmon (*Oncorhynchus tshawytscha*) are the most abundant anadromous fish in the Wenatchee River. A PCB burden in returning salmon could be transferred to the Wenatchee River food web when the salmon die and decay. This does not appear to be a significant PCB source.	Initial river survey of water to assess whether spawning areas suggest this is significant	Low

Table A-2: DDT sources, location, Phase 1 sampling approach, and rank of concern.

Source	Notes / Rationale	Sampling approach	Rank
Mission Creek sub-basin	The Mission Creek sub-basin has a 303(d) listing for 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT. This sub-basin is suspected of being the major source of DDT to the lower Wenatchee River.	Place SPMD above and below the confluence of Mission Creek and the Wenatchee River.	High
Irrigation returns	The main pathway for DDT to enter waterways from agricultural soils is through storm and irrigation runoff. Many minor irrigation returns were identified during a previous nutrient TMDL on the lower Wenatchee River (Carroll et al., 2006).	Assess major inputs through initial synoptic survey.	High
Stormwater discharges	Stormwater discharges from fruit packaging plants and orchard facilities to irrigation returns or ditches can contain residue pesticides. These discharge points will need identifying in the lower Wenatchee River.	Assess major inputs through initial synoptic survey.	Medium
Wastewater treatment facilities	Wastewater treatment plants can receive discharge waters from agricultural facilities. WWTP discharges may exist in Leavenworth, Peshastin, Dryden, Cashmere, and Wenatchee.	Assess major inputs through initial synoptic survey.	Medium
Contaminated Sites	There are two known historic landfill sites adjacent to the Wenatchee River (Cashmere and Dryden). Ecology does not consider these a concern. There could be more dump sites along the lower Wenatchee.	Assess major inputs through initial synoptic survey.	Medium

Appendix B. Study locations and methods.

Table B-1: Study site locations.

Site ID	Site name	Lat	Long	Notes
45CR468.4	Confluence SP	47.45756	-120.32854	Wenatchee R - Columbia R confluence in north bank backwater
45WR01.1	Hwy 285 bridge	47.45874	-120.33646	Wenatchee R under Hwy 285 bridge
45WR01.8	Wenatchee mainstem	47.46487	-120.35120	Wenatchee R upstream of Highline canal input
45WR03.4	Sleepy Hollow	47.47254	-120.37354	Wenatchee R upstream of Sleepy Hollow bridge at WDFW reclamation
45WR07.0	Old Monitor	47.50070	-120.42571	Wenatchee R under Old Monitor bridge
45WR09.5	Cotlets Way	47.52158	-120.45765	Wenatchee R upstream of Cotlets Way bridge
45WR11.4	Goodwin Br	47.52735	-120.48940	Wenatchee R under downstream side of Goodwin bridge
45WR15.4	Dryden	47.54108	-120.54645	Wenatchee R at Dryden WDFW public area
45WR21.3	Osprey	47.58224	-120.61520	Wenatchee R at Osprey Rafting Co facility
45WR28.5	Powerhouse	47.58660	-120.70760	Wenatchee R at former powerhouse site
45WR35.5	Tumwater	47.67623	-120.73454	Wenatchee R nr Hwy 2 bridge
45WR53.5	Lk Wenatchee	47.80985	-120.71523	Wenatchee R nr outlet from Lake Wenatchee, under Hwy 207 bridge
Tributaries				
45WHR8.8	White R	47.87435	-120.87067	White R nr ECY gaging stn 45K090
45MC00.1	Mission Cr	47.52239	-120.47514	Mission Cr nr confluence with Wenatchee R.
45PC00.3	Peshastin Cr	47.55761	-120.57611	Peshastin Cr nr confluences with Wenatchee R.
45IC02.2	Icicle Cr	47.56345	-120.66787	Icicle Cr at ECY gaging stn 45B070
45IC05.8	Icicle Cr diversion	47.54121	-120.72002	Icicle Cr at USGS gaging stn 12458000
45CC00.2	Chumstick Cr	47.60514	-120.64880	Chumstick Cr. prior to input from Icicle Irrigation District
Irrigation returns				
45HR00.1	Highline IR	47.46575	-120.35039	Highline IR prior to discharge into Wenatchee R.
45PI00.1	Peshastin IR	47.51692	-120.49375	Peshastin IR prior to discharge to Brender Cr.
45FR00.1	Icicle IR	47.47795	-120.42828	Icicle IR at the discharge point at Fairview Canyon Rd.

Table B-2: Measurement methods (laboratory).

Analyte	Sample Matrix	Expected Range of Results	Reporting Limit	Sample Prep Method	Analytical (Instrumental) Method
PCBs Congeners	Tissue	unknown	4 pg g-1 w/w per congener	EPA 1668C	EPA 1668C
Lipids	Tissue	0.5 - 2.0 %	0.10%	N/A	MEL SOP 730009
Ash-free dry mass	Tissue	60-90%	1.0 %	N/A	PSEP, 1986
C and N isotopes	Tissues	-2 to 10 ‰ N; -20 to -30 ‰ C	0.01 ‰	Lyophilization	Continuous flow isotope MS
PCBs Congeners	SPMD and SPE extract	100 - 200 ng (t-PCBs)	0.5 pg per congener	dialysis; EPA 1668C	EPA 1668C
t-DDT	SPMD and SPE extract	100 - 200 ng (t-DDT)	0.2 ng	dialysis; EPA 1699	EPA 1699
TSS	Surface water	5 - 200 mg L^{-1}	1 mg L^{-1}	N/A	EPA 160.2
DOC/TOC	Surface water	2 - 20 mg L^{-1}	1 mg L^{-1}	N/A	SM 5310B

C: carbon
N: nitrogen
DOC: dissolved organic carbon
TOC: total organic carbon
TSS: total suspended solids
SM: standard methods
SPE: solid phase extraction
SPMD: semi-permeable membrane device

Appendix C. Quality assurance objectives and results.

Table C-1: Measurement Quality Objectives.

Parameter	Verification Standards (LCS,CRM,CCV)	Duplicate Samples	Matrix Spikes	Matrix Spike-Duplicates	Surrogate Standards	Lowest Concentrations of Interest
	% Recovery Limits	Relative Percent Difference (RPD)	% Recovery Limits	Relative Percent Difference (RPD)	% Recovery Limits	Units of Concentration
Water samples						
TSS	80-120%	± 20%	NA	± 20%	NA	1 mg L^{-1}
TOC/DOC	80-120%	± 20%	75-125%	± 20%	NA	1 mg L^{-1}
SPMD and SPE						
PCB congeners	50-150%	± 20%	NA	NA	50-150%	50 pg per sample
t-DDT	50-150%	± 20%	50-150%	± 20%	50-150%	2 ng per sample
Tissue						
PCB congeners	50-150%	± 40%	NA	NA	50-150%	4 pg g^{-1}
lipids	75-125%	± 20%	NA	NA	NA	0.10%
ash-free dry weight	NA	± 20%	NA	NA	NA	1.00%
C and N isotopes	NA	± 20%	NA	NA	NA	0.01 ‰

LCS: laboratory control samples
CRM: certified reference materials
CCV: calibration verification standards
RPD: relative percent difference

Table C-2: Method, field and laboratory blanks.

Site	Sample Date	Lab ID	t-PCBs (pg/S)	t-PCBs (pg/L)	MDL (pg/L)	MQL (pg/L)	t-DDT (pg/S)	t-DDT (pg/L)	MDL (pg/L)	MQL (pg/L)
SPMDs										
Field Blank	Sept, 2014	1409069-39	3.97	22.68			0.37	1.98		
Day-0 Blank	Sept, 2014		3.05	17.11	31.70	59.30	0.24	1.29	3.10	6.50
Membrane Blank	Sept, 2014		0.04				0.11			
Field Blank (Osprey)	Sept, 2015	1510026-29	3.02	19.14			0.98	5.99		
Field Blank (Confluence)	Sept, 2015	1510026-30	2.34	15.09	23.60	38.20	0.80	4.89	7.50	13.10
Day-0 Blank	Sept, 2015	1510026-31	2.86	17.96			0.72	4.43		
Lab blank	Sept, 2015		0.60				0.27			
C.L.A.M.s	**Sample Date**		**t-PCBs (pg/S)**		**MDL (pg/S)**	**MQL (pg/S)**	**t-DDT (pg/S)**		**MDL (pg/S)**	**MQL (pg/S)**
Disk blank 1	5/14/2015		9367.08		15759.72	37649.80	258.20		327.27	457.70
Disk blank 2	5/14/2015		3129.06							
Disk blank 3	5/14/2015		6638.63							
Field blank	5/14/2015		1526.56				284.55			
Raw SPE media	5/14/2015		645.70		419.29					
Lab Blank	5/14/2015		192.88				284.40			
Disk blank	9/2/2015		ns				166.25		223.70	396.44
Field blank	9/2/2015		ns				120.30			
Lab Blank	9/2/2015		ns				138.65			
Lab Blank	9/2/2015		ns				173.50			

ns: not sampled

Table C-3: Sample precision for water. Bold values exceed method quality objectives for precision.

Site ID	Site name	Lab ID	sample date	TSS (mg/L)	RPD	DOC (mg/L)		RPD	TOC (mg/L)		RPD	t-PCBs	RPD	t-DDT	RPD
Grab Samples															
45WR07.0	Old Monitor	1408066-08	8/20/2014	5	0%	1	U	0%	1	U	0%				
45WR07.0 dup	Old Monitor	1408066-10	8/20/2014	5		1	U		1	U					
45WR07.0	Old Monitor	1409059-02	9/3/2014	2	0%	1	U	0%	1	U	0%				
45WR07.0DUP	Old Monitor	1409059-10	9/3/2014	2		1	U		1	U					
45WR01.1	Hwy 285 bridge	1409069-01	9/16/2014	4	22%	1	U	0%	1	U	0%				
45WR01.1 DUP	Hwy 285 bridge	1409069-10	9/16/2014	5		1	U		1	U					
45WR01.1	Hwy 285 bridge	1510026-02	9/28/2015	3	**120%**	1	U	0%	1.1		10%				
45WR01.1 dup	Hwy 285 bridge	1510026-03	9/28/2015	12		1	U		1	U					
45WR01.1	Hwy 285 bridge	1505051-23	5/11/2015	5	22%	1.1		0%	1.2		0%				
45WR01.1REP	Hwy 285 bridge	1505051-24	5/11/2015	4		1.1			1.2						
SPMD samples															
45WR01.1	Hwy 285 bridge	1409069-20	Sep-14									395.2	**74%**		
45WR01.1REP	Hwy 285 bridge	1409069-29	Sep-14									856.2			
C.L.A.M. samples															
45WR01.1	Hwy 285 bridge		5/12/2015									133.9	19%	290.9	7%
45WR01.1 REP	Hwy 285 bridge		5/12/2015									161.7		272.5	

Table C-4: Sample precision for tissues.

Site name	Site ID	Date	Biomass (g/cm2)	%OM	RPD	%lipids (AXYS)	RPD	t-PCBs (pg/g)	t-PCBs (pg/g OC)	RPD
Hwy 285 bridge	45WR01.1	9/16/2014	0.004838	0.284285	0.10	0.47	0.07	455.8496	64.59	0.06
Hwy 285 bridge	45WR01.1	9/16/2014	0.006997	0.257446		0.44		483.6431	68.53	

Bold values exceed method quality objectives for precision.

Site name	Site ID	Date	% N	RPD or RSD	$\delta^{15}N$ (permil)	RPD or RSD	% C	RPD or RSD	$\delta^{13}C$ (permil)	RPD or RSD
Biofilm										
Hwy 285 bridge	45WR01.1	9/16/2014	2.17	20%	6.07	2%	15.89	**22%**	-12.31	1%
Hwy 285 bridge	45WR01.1	9/16/2014	1.50		6.26		10.63		-12.49	
Hwy 285 bridge	45WR01.1	9/16/2014	2.15		6.25		15.99		-12.22	
Old Monitor	45WR07.0	9/16/2014	0.93	4%	6.00	1%	7.37	4%	-13.97	1%
Old Monitor	45WR07.0	9/16/2014	0.89		6.10		6.84		-13.99	
Old Monitor	45WR07.0	9/16/2014	0.87		6.10		6.86		-14.24	
Dryden	45WR15.4	9/16/2014	0.33	**96%**	5.35	7%	2.18	**102%**	-13.51	3%
Dryden	45WR15.4	9/16/2014	0.93		5.72		6.70		-13.13	
Tumwater	45WR35.5	9/17/2014	0.10	5%	1.03	18%	1.10	5%	-20.55	1%
Tumwater	45WR35.5	9/17/2014	0.10		0.74		1.11		-20.42	
Tumwater	45WR35.5	9/17/2014	0.11		0.80		1.20		-20.03	
Osprey	45WR21.3	9/15/2014	0.31	**42%**	2.60	12%	3.12	**42%**	-20.22	0%
Osprey	45WR21.3	9/15/2014	0.47		2.95		4.77		-20.15	
Icicle	45IC02.2	9/17/2014	0.22	1%	-0.94	12%	2.67	2%	-25.42	1%
Icicle	45IC02.2	9/17/2014	0.22		-0.83		2.62		-25.24	
Powerhouse	45WR28.5	9/17/2014	0.42	5%	1.45	18%	4.29	6%	-21.43	0%
Powerhouse	45WR28.5	9/17/2014	0.38		1.14		3.77		-21.59	
Powerhouse	45WR28.5	9/17/2014	0.42		1.64		4.02		-21.47	

Site name	Site ID	Date	% N	RPD or RSD	$\delta^{15}N$ (permil)	RPD or RSD	% C	RPD or RSD	$\delta^{13}C$ (permil)	RPD or RSD
Lk Wenatchee	45WR53.5	9/17/2014	0.26	**55%**	0.56	**40%**	2.76	**56%**	-19.98	2%
Lk Wenatchee	45WR53.5	9/17/2014	0.46		0.84		4.90		-20.41	
Peshastin Cr	45PC00_1_1	5/12/2015	0.12094	4%	1.6495	15%	1.3668	5%	-25.52	0%
Peshastin Cr	45PC00_1_2	5/12/2015	0.11616		1.413		1.3019		-25.5471	
Mainstem	45WR01_8_1	5/12/2015	0.42087	9%	4.2847	1%	4.0311	6%	-16.2943	0%
Mainstem	45WR01_8_2	5/12/2015	0.4816		4.3291		4.4971		-16.1838	
Mainstem	45WR01_8_3	5/12/2015	0.40882		4.3096		4.084		-16.2109	
Sleepy Hollow	45WR03_4_1	5/13/2015	0.26107	3%	1.6201	2%	2.5659	5%	-20.3266	1%
Sleepy Hollow	45WR03_4_2	5/13/2015	0.27153		1.6818		2.7601		-20.4181	
Sleepy Hollow	45WR03_4_3	5/13/2015	0.27544		1.6857		2.7988		-20.5417	
Old Monitor	45WR07_0_1	5/13/2015	0.1635	9%	2.4396	5%	1.4145	9%	-20.5126	0%
Old Monitor	45WR07_0_2	5/13/2015	0.15387		2.622		1.3011		-20.6011	
Old Monitor	45WR07_0_3	5/13/2015	0.18292		2.3936		1.5659		-20.4714	
Mission Cr	45MC00_1_1	5/13/2015	0.97972	**21%**	7.8815	1%	6.984	**21%**	-29.7996	1%
Mission Cr	45MC00_1_2	5/13/2015	1.2129		7.9777		8.645		-29.6377	
Cotlets Way	45WR09_5_1	5/13/2015	0.18656	2%	2.3301	6%	1.745	2%	-20.0331	1%
Cotlets Way	45WR09_5_2	5/13/2015	0.18309		2.405		1.7051		-19.83	
Cotlets Way	45WR09_5_3	5/13/2015	0.17882		2.1319		1.7834		-20.1567	
Hwy 285 bridge	45WR01_1_peri	9/21/2015	1.1675	11%	6.3816	2%	9.8324	11%	-15.5394	1%
Hwy 285 bridge	45WR01_1_peri	9/21/2015	1.2473		6.285		10.6121		-15.1945	
Hwy 285 bridge	45WR01_1_peri	9/21/2015	1.4537		6.1047		12.1345		-15.3095	
Sleepy Hollow	45WR03_4_peri	9/23/2015	0.97362	**59%**	5.1771	7%	7.5555	**59%**	-15.8429	2%
Sleepy Hollow	45WR03_4_peri	9/23/2015	0.53211		5.5507		4.1313		-16.219	
Old Monitor	45WR07_0_peri	9/23/2015	0.91974	1%	6.0735	10%	7.1865	9%	-15.1139	4%
Old Monitor	45WR07_0_peri	9/23/2015	0.93239		6.6808		6.5894		-14.4988	
Cotlets Way	45WR09_5_peri	9/23/2015	1.5046	**55%**	6.8651	2%	11.3342	**52%**	-14.8941	0%
Cotlets Way	45WR09_5_peri	9/23/2015	0.85393		6.7563		6.6806		-14.9525	
Goodwin	45WR11_4_peri	9/23/2015	1.8884	**25%**	5.5145	5%	13.0786	**40%**	-12.5114	1%

Site name	Site ID	Date	% N	RPD or RSD	$\delta^{15}N$ (permil)	RPD or RSD	% C	RPD or RSD	$\delta^{13}C$ (permil)	RPD or RSD
Goodwin	45WR11_4_peri	9/23/2015	2.435		5.7998		19.6909		-12.6733	
Osprey	45WR21_3_peri	9/22/2015	1.4108	0%	5.6595	0%	10.5849	7%	-12.4802	2%
Osprey	45WR21_3_peri	9/22/2015	1.4078		5.6343		11.4019		-12.7041	
Invertebrates										
Hwy 285 bridge	45WR01_1_inv	9/23/2015	7.1602	**27%**	9.3859	6%	41.5926	**27%**	-17.801	0%
Hwy 285 bridge	45WR01_1_inv	9/23/2015	7.1163		8.5097		43.3931		-17.8171	
Hwy 285 bridge	45WR01_1_inv	9/23/2015	4.2499		8.4815		25.1891		-17.9179	
Old Monitor	45WR07_0_inv	9/23/2015	7.5574	0%	8.4956	3%	42.5508	3%	-15.4335	1%
Old Monitor	45WR07_0_inv	9/23/2015	7.5283		8.7857		41.1544		-15.3417	
Cotlets Way	45WR09_5_inv	9/23/2015	5.6354	14%	8.3355	2%	33.6747	13%	-16.7382	0%
Cotlets Way	45WR09_5_inv	9/23/2015	6.5011		8.5017		38.2233		-16.711	
Osprey	45WR21_3_inv	9/22/2015	8.7769	2%	8.1461	3%	45.6344	4%	-15.4063	2%
Osprey	45WR21_3_inv	9/22/2015	8.9902		7.8873		47.4388		-15.7561	
Mountain whitefish										
Confluence	MWF_1_1	5/18/2015	12.7231	1%	11.5682	2%	45.0314	2%	-22.4981	0%
Confluence	MWF_1_2	5/18/2015	12.5878		11.7731		46.1377		-22.4189	
Confluence	MWF_3_1	5/18/2015	13.1746	1%	12.0854	2%	44.9445	2%	-19.3853	1%
Confluence	MWF_3_2	5/18/2015	13.1486		11.6666		46.5351		-19.6239	
Confluence	MWF_3_3	5/18/2015	12.983		11.8045		44.4142		-19.4334	
Confluence	MWF_4_1	5/18/2015	12.7202	4%	11.7001	1%	45.5177	2%	-17.8785	2%
Confluence	MWF_4_2	5/18/2015	12.2588		11.6047		46.369		-18.2043	
Confluence	MWF_5_1	5/18/2015	12.4936	6%	11.0531	0%	46.7592	4%	-16.8409	1%
Confluence	MWF_5_2	5/18/2015	13.2793		11.0794		45.1318		-16.6304	
Confluence	MWF_6_1	5/18/2015	13.4354	3%	12.2619	2%	44.3235	3%	-19.0234	1%
Confluence	MWF_6_2	5/18/2015	13.6243		12.0794		43.7548		-19.2149	
Confluence	MWF_6_3	5/18/2015	14.2088		12.5319		46.5586		-18.8329	
Osprey	MWF_17_1	5/19/2015	13.6133	1%	10.3226	3%	48.201	0%	-19.231	1%
Osprey	MWF_17_2	5/19/2015	13.5385		10.6486		47.9957		-19.0717	

Site name	Site ID	Date	% N	RPD or RSD	δ^{15}N (permil)	RPD or RSD	% C	RPD or RSD	δ^{13}C (permil)	RPD or RSD
Osprey	MWF_18_1	5/19/2015	13.1241	0%	10.7154	2%	48.7253	1%	-18.5154	0%
Osprey	MWF_18_2	5/19/2015	13.0866		10.3641		48.022		-18.5386	
Osprey	MWF_18_3	5/19/2015	13.0492		10.4785		48.4702		-18.4882	
Osprey	MWF_19_1	5/19/2015	13.8865	8%	10.8643	3%	46.1882	2%	-16.7697	2%
Osprey	MWF_19_2	5/19/2015	12.7544		10.5625		45.2101		-17.0338	
Osprey	MWF_20_1	5/19/2015	12.8341	2%	11.4029	2%	48.3553	1%	-17.7252	1%
Osprey	MWF_20_2	5/19/2015	12.4584		11.7563		49.6366		-17.8431	
Osprey	MWF_20_3	5/19/2015	13.0098		11.7057		48.6296		-17.6274	
Confluence	MWF_1	9/21/2015	12.9997	1%	13.1038	0%	49.0511	0%	-27.3397	0%
Confluence	MWF_1	9/21/2015	12.8158		13.03		49.0125		-27.5619	
Confluence	MWF_1	9/21/2015	13.1246		13.0573		48.9406		-27.3548	
Osprey	MWF_22	9/22/2015	13.0971	5%	9.953	1%	49.4914	4%	-18.2462	1%
Osprey	MWF_22	9/22/2015	11.9803		10.0157		45.7844		-18.3991	
Osprey	MWF_22	9/22/2015	12.7873		9.9136		47.481		-18.204	

Bold values exceed method quality objectives for precision.
OM: organic matter
OC: organic carbon
RSD: relative standard deviation

Table C-5: Performance reference compounds recovery - indicating SPMD sample bias.

Site	Site name	Lab ID	Deployment time	PCB-14 (ng/S)	PCB-14 (%)	PCB-31L (ng/S)	PCB-31L (%)	PCB-50 (ng/S)	PCB-50 (%)	PCB-95 (ng/S)	PCB-95 (%)	PCB-153 (ng/S)	PCB-153 (%)
September, 2014													
45WR01.1	Confluence	1409069-20	27.1	1.72	77%	3.40	89%	2.00	**101%**	2.67	77%	-	-
45WR01.1 dup	Confluence	1409069-29	27.1	1.67	74%	3.16	83%	2.84	**143%**	3.55	**103%**	-	-
45WR07.0	Old Monitor	1409069-21	27.0	1.75	78%	3.42	90%	1.82	91%	2.79	81%	-	-
45WR15.4	Dryden	1409069-22	26.8	1.30	58%	2.92	76%	1.63	82%	2.68	78%	-	-
45WR21.3	Osprey	1409069-23	28.2	1.53	68%	2.93	77%	1.56	78%	2.93	85%	-	-
45WR28.5	Powerhouse	1409069-24	29.0	1.61	72%	3.03	79%	1.67	84%	2.54	74%	-	-
45IC02.2	Icicle	1409069-25	29.1	1.60	71%	3.04	80%	1.70	85%	2.74	80%	-	-
45WR35.5	Tumwater	1409069-26	29.0	1.30	58%	2.76	72%	1.48	74%	3.48	**101%**	-	-
45WR53.5	Lk Wenatchee	1409069-27	29.0	1.80	80%	3.26	85%	1.72	87%	3.38	98%	-	-
45WHR8.8	White R	1409069-28	29.0	1.55	69%	3.11	81%	1.76	88%	3.34	97%	-	-
	Field Blank	1409069-39		2.20		3.66		1.86		3.18		-	
	Day-0 Blank	-		2.30		3.98		2.12		3.72		-	
September, 2015													
45CR468.4	Confluence SP	1510026-20	26.0	2.98	83%	2.20	90%	-	-	2.66	98%	2.54	96%
45WR01.1	Hwy 285 bridge	1510026-21	26.0	2.94	82%	2.22	91%	-	-	2.64	97%	2.54	96%
45WR01.8	Wenatchee mainstem	1510026-22	26.1	2.74	77%	2.08	85%	-	-	2.52	92%	2.42	91%
45WR03.4	Sleepy Hollow	1510026-23	26.9	3.00	84%	2.12	87%	-	-	2.60	95%	2.48	93%
45WR07.0	Old Monitor	1510026-24	27.0	3.12	87%	2.10	86%	-	-	2.42	89%	2.62	99%
45WR09.5	Cotlets Way	1510026-25	27.0	1.90	53%	1.61	66%	-	-	2.32	85%	2.54	96%
45WR11.4	Goodwin Br	1510026-26	27.2	2.84	79%	2.02	83%	-	-	2.56	94%	2.56	96%
45WR21.3	Osprey	1510026-27	27.8	2.94	82%	2.04	83%	-	-	2.48	91%	2.50	94%
45IC02.2	Icicle	1510026-28	27.9	2.48	69%	1.89	77%	-	-	2.36	87%	2.54	96%
	Field Blank (Osprey)	1510026-29		3.58		2.40		-		2.66		2.64	
	Field Blank (Confluence)	1510026-30		3.58		2.46		-		2.68		2.56	
	Day-0 Blank	1510026-31		3.56		2.48				2.84		2.76	

Appendix D. Study results.

Table D-1: Estimated PCB concentrations in water from SPMDs. Bold results are above site-specific background, shaded cells highlight the dominant homolog group.

September, 2014										
Site ID	**45WR01.1**	**45WR01.1 dup**	**45WR07.0**	**45WR15.4**	**45WR21.3**	**45WR28.5**	**45IC02.2**	**45WR35.5**	**45WR53.5**	**45WHR8.8**
Site Name	**Hwy 285 bridge**	**Hwy 285 bridge**	**Old Monitor**	**Dryden**	**Osprey**	**Powerhouse**	**Icicle**	**Tumwater**	**Lake Wenatchee**	**White River**
Lab ID	**1409069-20**	**1409069-29**	**1409069-21**	**1409069-22**	**1409069-23**	**1409069-24**	**1409069-25**	**1409069-26**	**1409069-27**	**1409069-28**
1-CB	1.6	2.9	0.3	0.1	0.1	0.1	0.0	0.0	0.0	0.0
2-CB	46.3	74.4	4.1	1.7	1.3	1.5	1.8	1.2	2.4	1.5
3-CB	112.2	423.0	22.8	8.5	6.9	8.2	10.0	5.9	13.8	10.6
4-CB	87.7	218.1	66.4	11.6	8.0	9.1	15.2	7.2	17.4	14.6
5-CB	89.5	89.9	146.4	8.4	5.4	4.2	13.8	3.9	8.2	7.4
6-CB	50.9	42.7	88.6	6.2	4.5	4.0	9.2	3.4	7.5	6.4
7-CB	6.2	4.4	10.2	1.3	1.1	1.3	2.2	0.8	1.8	1.5
8-CB	0.5	0.6	0.7	0.2	0.2	0.2	0.3	0.1	0.2	0.2
9-CB	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.1	0.1
10-CB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
t-PCBs	**395.2**	**856.2**	**339.7**	38.2	27.5	28.5	52.5	22.6	51.5	42.2
September, 2015										
Site ID	**45CR468.4**	**45WR01.1**	**45WR01.8**	**45WR03.4**	**45WR07.0**	**45WR09.5**	**45WR11.4**	**45WR21.3**	**45IC02.2**	
Site Name	**Confluence SP**	**Hwy 285 bridge**	**Wenatchee mainstem**	**Sleepy Hollow**	**Old Monitor**	**Cotlets Way**	**Goodwin Br**	**Osprey**	**Icicle**	
Lab ID	**1510026-20**	**1510026-21**	**1510026-22**	**1510026-23**	**1510026-24**	**1510026-25**	**1510026-26**	**1510026-27**	**1510026-28**	
1-CB	2.4	4.2	0.2	0.3	0.1	0.0	0.1	0.0	0.0	
2-CB	99.0	211.8	23.7	14.6	7.5	4.0	3.3	2.5	1.7	
3-CB	328.9	679.1	103.1	46.2	29.1	14.8	13.1	11.3	9.4	
4-CB	265.9	480.0	95.6	74.1	65.7	65.8	16.7	14.6	12.3	

5-CB	114.7	152.9	86.8	122.1	135.0	135.8	9.9	10.2	10.3	
6-CB	42.4	44.0	38.3	50.5	65.0	47.7	5.9	6.7	6.3	
7-CB	8.6	7.4	5.2	7.9	9.0	5.0	1.9	2.3	2.1	
8-CB	1.5	0.4	0.5	1.0	1.5	0.5	0.4	0.5	0.5	
9-CB	0.3	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	
10-CB	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	
t-PCBs	**863.7**	**1580.0**	**353.5**	**316.8**	**313.0**	**273.7**	51.5	48.1	42.6	

CB: chloro biphenyl homolog groups

Table D-2: Estimated DDT concentrations in water from SPMDs. Bold results are above equipment contamination background.

September, 2014									
	45WR01.1	45WR07.0	45WR15.4	45WR21.3	45WR28.5	45IC02.2	45WR35.5	45WR53.5	45WHR8.8
	Hwy 285 bridge	Old Monitor	Dryden	Osprey	Powerhouse	Icicle	Tumwater	Lake Wenatchee	White River
	1409069-20	1409069-21	1409069-22	1409069-23	1409069-24	1409069-25	1409069-26	1409069-27	1409069-28
o,p'-DDE	27.9	2.9	2.6	0.8	0.3	0.4	0.3	0.4	0.4
p,p'-DDE	954.8	204.4	196.9	54.0	8.0	13.4	9.1	12.2	8.4
o,p'-DDD	27.4	15.8	15.7	5.4	1.4	1.1	1.7	2.0	1.0
o,p'-DDT	157.6	13.8	14.7	5.0	2.1	2.2	2.0	3.0	2.2
p,p'-DDD	57.2	47.1	51.4	19.4	4.5	4.8	5.8	6.6	3.2
p,p'-DDT	548.6	57.7	61.6	21.2	7.1	7.0	7.5	8.7	7.2
t-DDT (pg/L)	**1773.5**	**341.7**	**343.0**	**105.9**	23.3	28.9	26.3	32.9	22.5
September, 2015									
	45WR01.1	45WR01.8	45WR07.0						
	Hwy 285 bridge	Wenatchee mainstem	Old Monitor						
	1510026-21	1510026-22	1510026-24						
o,p'-DDE	13.6	13.0	12.9						
p,p'-DDE	865.6	883.6	947.3						
o,p'-DDD	82.1	90.6	92.4						
o,p'-DDT	51.9	46.9	55.2						
p,p'-DDD	225.7	235.7	250.0						
p,p'-DDT	209.6	202.3	222.2						
t-DDT (pg/L)	**1448.4**	**1472.0**	**1580.1**						

Table D-3: Ancillary data collected during SPMD deployment.

Site ID	Site name	Lab ID	Sample Date	SPMD stage	TSS (mg/L)		DOC (mg/L)		TOC (mg/L)		pH	Temperature	Conductivity
Initial 2014 Survey													
45WR01.1	Hwy 285 bridge	1408066-07	8/20/2014	SPMD deploy	5		1	U	1	U	7.23	19.5	56
45WR07.0	Old Monitor	1408066-08	8/20/2014	SPMD deploy	5		1	U	1	U	7.29	20.5	50
45WR07.0 dup		1408066-10	8/20/2014	SPMD deploy	5		1	U	1	U			
45WR15.4	Dryden	1408066-09	8/20/2014	SPMD deploy	6		1	U	1	U	7.02	22.8	41
45WR21.3	Osprey	1408066-01	8/18/2014	SPMD deploy	4		1	U	1	U	7.09	21.6	26
45WR28.5	Powerhouse	1408066-03	8/19/2014	SPMD deploy	6		1	U	1	U	7.13	20.2	29
45IC02.2	Icicle	1408066-02	8/18/2014	SPMD deploy	2		1	U	1	U	7.12	19.5	34
45WR35.5	Tumwater	1408066-04	8/19/2014	SPMD deploy	26		1	U	1	U	7	20.6	31
45WR53.5	Lk Wenatchee	1408066-05	8/19/2014	SPMD deploy	2		1	U	1	U	6.99	21	28
45WHR8.8	White R	1408066-06	8/19/2014	SPMD deploy	4		1	U	1	U	7.01	16	15
45WR01.1	Hwy 285 bridge	1409059-01	9/3/2014	SPMD midpoint	2		1	U	1	U	7.04	15.9	65
45WR07.0	Old Monitor	1409059-02	9/3/2014	SPMD midpoint	2		1	U	1	U	7.28	16.3	55
45WR07.0DUP	Old Monitor	1409059-10	9/3/2014	SPMD midpoint	2		1	U	1	U			
45WR15.4	Dryden	1409059-03	9/3/2014	SPMD midpoint	2		1	U	1	U	7.16	17.9	43
45WR21.3	Osprey	1409059-04	9/3/2014	SPMD midpoint	1		1	U	1	U	7.19	17.1	38
45WR28.5	Powerhouse	1409059-05	9/2/2014	SPMD midpoint	2		1	U	1	U	7.32	18.6	33
45IC02.2	Icicle	1409059-06	9/2/2014	SPMD midpoint	1	U	1	U	1	U	7.16	16.7	27
45WR35.5	Tumwater	1409059-07	9/2/2014	SPMD midpoint	2		1	U	1	U	7.07	18.6	32
45WR53.5	Lk Wenatchee	1409059-08	9/2/2014	SPMD midpoint	1		1	U	1	U	7.22	16.8	10
45WHR8.8	White R	1409059-09	9/2/2014	SPMD midpoint	2		1	U	1	U	7	13.3	21
45WR01.1	Hwy 285 bridge	1409069-01	9/16/2014	SPMD retrieval	4		1	U	1	U	6.99	18.3	45
45WR01.1 DUP	Hwy 285 bridge	1409069-10	9/16/2014	SPMD retrieval	5		1	U	1	U			
45WR07.0	Old Monitor	1409069-02	9/16/2014	SPMD retrieval	2		1	U	1	U	6.93	16.3	45
45WR15.4	Dryden	1409069-03	9/16/2014	SPMD retrieval	2		1	U	1	U	6.89	13.6	63.3

Site ID	Site name	Lab ID	Sample Date	SPMD stage	TSS (mg/L)		DOC (mg/L)		TOC (mg/L)		pH	Temperature	Conductivity
45WR21.3	Osprey	1409069-04	9/15/2014	SPMD retrieval	1		1	U	1	U	6.88	21.2	49.5
45WR28.5	Powerhouse	1409069-05	9/17/2014	SPMD retrieval	1		1	U	1	U	6.79	16.2	47
45IC02.2	Icicle	1409069-06	9/16/2014	SPMD retrieval	1	U	1	U	1	U	7	15.4	36.4
45WR35.5	Tumwater	1409069-07	9/17/2014	SPMD retrieval	1		1	U	1	U	6.75	15.9	44.2
45WR53.5	Lk Wenatchee	1409069-08	9/17/2014	SPMD retrieval	1	U	1	U	1	U	6.9	16.7	45.8
45WHR8.8	White R	1409069-09	9/17/2014	SPMD retrieval	3		1	U	1	U	6.79	13.6	34.3
Detailed 2015 Survey													
45CR468.4	Confluence SP	1509064-15	9/2/2015	SPMD deploy	1		1.1		1.1		8.37	20.28	128.8
45WR01.1	Hwy 285 bridge	1509064-14	9/2/2015	SPMD deploy	4		1.1		1.1		8.49	18.43	85
45WR01.8	Wenatchee mainstem	1509064-13	9/2/2015	SPMD deploy	4		1.1		1		8.42	17.54	78.8
45WR03.4	Sleepy Hollow	1509064-12	9/1/2015	SPMD deploy	3		1.7		1		8.87	18.33	79
45WR07.0	Old Monitor	1509064-11	9/1/2015	SPMD deploy	3		1	U	1	U	8.98	18.18	73.2
45WR09.5	Cotlets Way	1509064-10	9/1/2015	SPMD deploy	3		1	U	1	U	8.93	18.08	75.1
45WR11.4	Goodwin Br	1509064-09	9/1/2015	SPMD deploy	2		1	U	1	U	8.92	17.91	71.3
45WR21.3	Osprey	1509064-08	9/1/2015	SPMD deploy	2		1	U	1	U	8.48	16.76	47.3
45IC02.2	Icicle	1509064-07	9/1/2015	SPMD deploy	1	U	1	U	1	U	7.52	13.92	34.4
45CR468.4	Confluence SP	1509091-09	9/15/2015	SPMD midpoint	1	U	1	U	1.1				
45WR01.1	Hwy 285 bridge	1509091-08	9/15/2015	SPMD midpoint	3		1	U	1.1				
45WR01.8	Wenatchee mainstem	1509091-07	9/15/2015	SPMD midpoint	2		1	U	1	U			
45WR03.4	Sleepy Hollow	1509091-06	9/15/2015	SPMD midpoint	2		1	U	1	U			
45WR07.0	Old Monitor	1509091-05	9/15/2015	SPMD midpoint	2		1	U	1	U			
45WR09.5	Cotlets Way	1509091-04	9/15/2015	SPMD midpoint	2		1	U	1	U			
45WR11.4	Goodwin Br	1509091-03	9/15/2015	SPMD midpoint	2		1	U	1	U			
45WR21.3	Osprey	1509091-02	9/15/2015	SPMD midpoint	1	U	1	U	1	U			
45IC02.2	Icicle	1509091-01	9/15/2015	SPMD midpoint	1	U	1	U	1	U			
45CR468.4	Confluence SP	1510026-01	9/28/2015	SPMD retrieval	1	U	1	U	1	U	7.84	15.3	112

Site ID	Site name	Lab ID	Sample Date	SPMD stage	TSS (mg/L)		DOC (mg/L)		TOC (mg/L)		pH	Temperature	Conductivity
45WR01.1	Hwy 285 bridge	1510026-02	9/28/2015	SPMD retrieval	3		1	U	1.1		8.4	14.4	97
45WR01.1 dup	Hwy 285 bridge	1510026-03	9/28/2015	SPMD retrieval	12		1	U	1	U			
45WR01.8	Wenatchee mainstem	1510026-04	9/28/2015	SPMD retrieval	2		1	U	1	U	8.6	14.5	94.9
45WR03.4	Sleepy Hollow	1510026-05	9/28/2015	SPMD retrieval	2		1	U	1		8.83	14.59	91.6
45WR07.0	Old Monitor	1510026-06	9/28/2015	SPMD retrieval	2		1	U	1	U	8.82	14.36	85.1
45WR09.5	Cotlets Way	1510026-07	9/28/2015	SPMD retrieval	2		1	U	1	U	8.76	14.27	86.4
45WR11.4	Goodwin Br	1510026-08	9/28/2015	SPMD retrieval	2		1	U	1	U	8.72	14.17	79.3
45WR21.3	Osprey	1510026-10	9/29/2015	SPMD retrieval	1		1	U	1	U	7.6	10.25	50
45IC02.2	Icicle	1510026-09	9/29/2015	SPMD retrieval	1		1	U	1	U	7.62	8.47	43.5

U: The analyte was not detected above the reported sample quantitation limit.

Table D-4: Estimated concentrations of PCBs and DDT from C.L.A.M. devices.

Site	Sample date	Deployment time (min)	Final sample volume (L)	t-DDT (pg/S)[‡]	t-DDT (pg/L)		t-PCBs (pg/S)[†]	t-PCBs (pg/L)	
Mainstem									
45CR468.4	5/12/2015	1695	21.3	5458.2	256.9	J	14672.5	690.5	
45WR01.1	5/12/2015	1343	29.7	8625.3	290.9	J	3970.5	133.9	U
45WR01.1 REP	5/12/2015	1341	25.2	6866.6	272.5	J	4074.5	161.7	U
45WR01.8	5/12/2015	1850	9.0	2316.6	257.4	J	3054.1	339.3	U
45WR03.4	5/12/2015	1581	11.1	ns	ns		2619.1	235.1	U
45WR07.0	5/12/2015	1570	12.4	2366.5	191.6	J	2007.9	162.6	U
45WR09.5	5/13/2015	1565	8.0	ns	ns		3462.5	430.7	U
45WR11.4	5/13/2015	1495	15.4	ns	ns		3304.2	215.3	U
45WR21.3	5/13/2015	2387	12.1	249	20.7	UJ	2202.5	182.8	U
Tributaries									
45MC00.1	5/13/2015	1420	14.0	76196	5434.8		3288.7	234.6	U
45PC00.3	5/13/2015	2485	9.2	943.5	102.6	J	ns	ns	
45IC02.2	5/14/2015	1492	24.2	ns	ns		2551.4	105.6	U
45IC05.8	5/14/2015	1422	9.0	99.9	11.1	UJ	2762.1	306.9	U
45CC00.2	5/14/2015	1410	7.7	58354	7578.4		ns	ns	
45MC00.1	9/3/2015	4038	34.6	132630	3838.8		ns	ns	
45PC00.3	9/3/2015	3775	106.5	38437	360.9		ns	ns	
45CC00.2	9/3/2015	3717	72.6	470870	6485.8		ns	ns	
Irrigation returns									
45HR00.1	5/12/2015	1509	45.6	42936	941.6		ns	ns	
45PI00.1	5/14/2015	2365	24.1	250870	10409.5		ns	ns	
45FR00.1	5/14/2015	1418	11.2	29277	2610.1	J	ns	ns	
45HR00.1	9/3/2015	3992	48.1	18701	388.8		ns	ns	
45PI00.1	9/3/2015	4015	62.2	130741	2103.6		ns	ns	
45FR00.1	9/3/2015	4002	58.4	48143	824.7		ns	ns	

Notes for Table D-4:

ns: not sampled

ł equipment contamination is 275 pg/S in May 2015 and 145 pg/S in September 2015

† equipment contamination is 5175 pg/S in May 2015

U: The analyte was not detected above the reported sample quantitation limit.

J: The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample

pg/S: picograms per sample

Table D-5: Ancillary data collected during C.L.A.M. deployment.

Site ID	Site name	Lab ID	Sample date	TSS (mg/L)		DOC (mg/L)		TOC (mg/L)	pH	Temperature (°C)	Conductivity (µS/cm)	Dissolved oxygen (mg/L)
45CR468.4	Confluence	1505051-22	5/11/2015	3		1.6		1.7	8.02	11.111	122.1	11.585
45WR01.1	Hwy 285 bridge	1505051-23	5/11/2015	5		1.1		1.2	8.06	11.91	42.7	11.425
45WR01.1REP	Hwy 285 bridge	1505051-24	5/11/2015	4		1.1		1.2				
45WR01.8	Mainstem	1505051-21	5/11/2015	4		1		1.6	7.76	11.045	44	11.505
45WR03.4	Sleepy Hollow	1505051-25	5/11/2015	7		1.1		1.2	8.18	11.49	41.9	11.48
45WR07.0	Old Monitor	1505051-26	5/11/2015	5		1	U	1.1	8.04	11.305	41.2	11.405
45WR09.5	Cotlets Way	1505051-29	5/12/2015	9		1.1		1.2	7.65	10.055	42.1	11.515
45WR11.4	Goodwin Br	1505051-31	5/12/2015	5		1		1.2	7.70	9.895	38.55	11.64
45WR21.3	Osprey	1505051-28	5/11/2015	3		1	U	1.2	7.56	10.415	33.9	11.155
45MC00.1	Mission Cr	1505051-30	5/12/2015	203	J	2.6		2.8	7.97	10.5185	195.3	10.505
45MC00.1	Mission Cr	1505051-37*	5/13/2015	446	J	ns		3.7				
45PC00.3	Peshastin Cr	1505051-27	5/11/2015	3		1	U	1	8.11	10.735	104.95	10.935
45IC02.2	Icicle Cr	1505051-33	5/13/2015	3		1.2		1.3	7.52	7.3	36.3	11.83
45IC05.8	Icicle Intake	1505051-34	5/13/2015	3		1.2		1.3	7.70	6.8	35.65	12.12
45CC00.2	Chumstick Cr	1505051-35	5/13/2015	15		2.1		2.2	7.82	9.46	343.3	10.29
45HR00.1	Highline IR	1505051-20	5/11/2015	6		1.3		1.4	7.51	11.985	36.55	10.77
45PI00.1	Peshastin IR	1505051-32	5/12/2015	6		1.5		1.7	8.08	9.875	105.8	11.375
45FR00.1	Icicle IR	1505051-36	5/13/2015	5		1.4		1.5	7.64	9.345	36.95	11.24
45MC00.1	Mission Cr	1509064-2	9/3/2015	8		1.2		1.4	7.49	14.205	210.6	8.21
45PC00.3	Peshastin Cr	1509064-5	9/3/2015	2		1	U	1	8.09	14.295	119.4	10.095
45CC00.2	Chumstick Cr	1509064-6	9/3/2015	3		1	U	1	7.41	10.885	320.85	8.44
45HR00.1	Highline IR	1509064-4	9/3/2015	2		1	U	1	7.82	16.8	50.2	9.64
45PI00.1	Peshastin IR	1509064-1	9/3/2015	2		1	U	1	8.13	14.85	107.8	10.19
45FR00.1	Icicle IR	1509064-3	9/3/2015	4		1	U	1	7.73	14.6	52.3	9.915

* grab sample not composite. U: The analyte was not detected above the reported sample quantitation limit.

J: The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

Table D-6: PCB and DDT concentrations in biofilms (periphyton). Ancillary data includes biomass, stable isotopes and % lipids.

Site ID	Site name	date	area (cm^2)	dry mass (g)	biomass (g/cm2)	$\delta^{15}N$	$\delta^{13}C$	%lipids	t-PCBs (pg/g)	t-PCBs (pg/g OC)	t-DDT (pg/g)	t-DDT (pg/g OC)
Initial Sampling 2014												
45WR01.1	Hwy 285 bridge	9/16/2014	2244.0	10.9	0.0048	6.2	-12.3	0.47	455.8	64.6	ns	ns
45WR07.0	Old Monitor	9/16/2014	1134.5	8.6	0.0076	6.1	-14.1	0.17	580.9	40.8	ns	ns
45WR15.4	Dryden	9/16/2014	2400.5	10.2	0.0042	5.5	-13.3	0.37	39.7	1.8	ns	ns
45WR21.3	Osprey	9/15/2014	3243.4	13.7	0.0042	2.8	-20.2	0.073	89.3	3.5	ns	ns
45IC02.2	Icicle	9/17/2014	1179.3	14.0	0.0118	-0.9	-25.3	0.044	180.1	4.8	ns	ns
45WR28.5	Powerhouse	9/17/2014	1135.4	4.4	0.0039	1.4	-21.5	0.021	15.6	0.6	ns	ns
45WR35.5	Tumwater	9/17/2014	2697.0	121.5	0.0451	0.9	-20.3	0.06	18.0	0.2	ns	ns
45WR53.5	Lk Wenatchee	9/17/2014	2077.0	11.6	0.0056	0.7	-20.2	0.072	7.1	0.3	ns	ns
Detailed Sampling 2015												
45WR01.8	Mainstem Highline	5/12/2015	524.0	0.5	0.0009	4.3	-16.2	0.067	65.0	2.7	617.5	26.0
45WR03.4	Sleepy Hollow	5/13/2015	732.0	0.6	0.0008	1.7	-20.4	0.061	350.3	9.5	ns	ns
45WR07.0	Old Monitor	5/13/2015	908.0	1.0	0.0011	2.5	-20.5	0.036	895.0	12.8	ns	ns
45WR09.5	Cotlets Way	5/13/2015	1393.0	0.8	0.0006	2.3	-20.0	0.057	1611.9	28.1	ns	ns
45PC00.1	Peshastin Cr	5/12/2015	1223.0	1.4	0.0011	1.5	-25.5	ns	ns	ns	ns	ns
45MC00.1	Mission Cr	5/13/2015	600.0	0.2	0.0003	7.9	-29.7	0.17	82.6	6.5	3459.3	270.3
45WR01.1	Hwy 285 bridge	9/21/2015	2240.1	6.9	0.0031	6.3	-15.3	0.11	1270.1	137.9	783.2	85.1
45WR03.4	Sleepy Hollow	9/23/2015	781.7	3.7	0.0048	5.4	-16.0	0.092	444.1	26.0	ns	ns
45WR07.0	Old Monitor	9/23/2015	1056.2	1.6	0.0015	6.4	-14.8	0.099	755.3	52.0	ns	ns
45WR09.5	Cotlets Way	9/23/2015	858.5	4.1	0.0048	6.8	-14.9	0.19	380.8	34.3	ns	ns
45WR11.4	Goodwin	9/23/2015	710.3	3.4	0.0048	5.7	-12.6	0.23	24.6	4.0	ns	ns
45WR21.3	Osprey	9/22/2015	1742.7	2.4	0.0014	5.6	-12.6	0.1	42.5	4.7	ns	ns

OC: organic carbon
ns: not sampled

Table D-7: Taxonomy of the periphyton samples.

Date	Taxon	Type	45IC02.2	45MC00.1	45PC00.1	45WR01.1	45WR01.8	45WR03.4	45WR07.0	45WR09.5	45WR11.4	45WR15.4	45WR21.3	45WR28.5	45WR35.5	45WR53.5
9/15/2014	Achnanthidium minutissimum	Diatom	-	-	-	H	-	-	H	-	-	H	M	-	M	H
9/15/2014	Aulacoseira	Diatom	M	-	-	-	-	-	-	-	-	-	-	-	-	-
9/15/2014	Cocconeis	Diatom	-	-	-	-	-	-	L	-	-	-	-	-	-	L
9/15/2014	Cymbella	Diatom	-	-	-	-	-	-	-	-	-	M	L	-	L	-
9/15/2014	Cymbella/Encyonema	Diatom	M	-	-	-	-	-	-	-	-	-	-	-	-	M
9/15/2014	Didymosphenia geminata	Diatom	M	-	-	L	-	-	M	-	-	-	L	M	L	L
9/15/2014	Encyonema	Diatom	-	-	-	-	-	-	-	-	-	-	L	L	L	-
9/15/2014	Gomphonema	Diatom	M	-	-	M	-	-	-	-	-	-	-	-	-	-
9/15/2014	Hannaea	Diatom	M	-	-	-	-	-	-	-	-	-	-	-	-	-
9/15/2014	Navicula	Diatom	M	-	-	-	-	-	-	-	-	-	L	L	L	-
9/15/2014	Oedogonium	Green	-	-	-	-	-	-	-	-	-	L	-	-	-	-
9/15/2014	Pinnularia	Diatom	M	-	-	-	-	-	-	-	-	-	-	-	-	-
9/15/2014	Surirella	Diatom	M	-	-	-	-	-	-	-	-	-	-	-	-	-
9/15/2014	Synedra	Diatom	M	-	-	M	-	-	M	-	-	-	H	M	H	M
9/15/2014	Tabellaria	Diatom	-	-	-	-	-	-	-	-	-	-	L	-	L	L
9/15/2014	Unknown desmid	Desmid	-	-	-	-	-	-	-	-	-	L	-	-	-	-
5/15/2015	Achnanthidium minutissimum	Diatom	-	M	M	-	M	M	M	L	-	-	-	-	-	-
5/15/2015	Aulacoseira	Diatom	-	-	-	-	-	-	L	-	-	-	-	-	-	-
5/15/2015	Cladophora	Green	-	H	-	-	-	-	-	-	-	-	-	-	-	-
5/15/2015	Cymbella	Diatom	-	-	-	-	L	-	-	-	-	-	-	-	-	-
5/15/2015	Cymbella/Encyonema	Diatom	-	-	-	-	-	H	M	M	-	-	-	-	-	-
5/15/2015	Diatoma vulgare	Diatom	-	M	H	-	L	-	-	L	-	-	-	-	-	-
5/15/2015	Didymosphenia geminata	Diatom	-	-	-	-	M	M	H	M	-	-	-	-	-	-
5/15/2015	Encyonema	Diatom	-	-	M	-	L	-	-	-	-	-	-	-	-	-
5/15/2015	Fragilaria	Diatom	-	-	-	-	-	-	L	-	-	-	-	-	-	-

Date	Taxon	Type	45IC02.2	45MC00.1	45PC00.1	45WR01.1	45WR01.8	45WR03.4	45WR07.0	45WR09.5	45WR11.4	45WR15.4	45WR21.3	45WR28.5	45WR35.5	45WR53.5
5/15/2015	Hannaea arcus	Diatom	-	-	L	-	M	H	M	H	-	-	-	-	-	-
5/15/2015	Melosira	Diatom	-	-	-	-	-	L	L	-	-	-	-	-	-	-
5/15/2015	Navicula	Diatom	-	-	-	-	M	L	-	-	-	-	-	-	-	-
5/15/2015	Nitzschia	Diatom	-	L	-	-	-	-	-	-	-	-	-	-	-	-
5/15/2015	Stigeoclonium	Green	-	H	-	-	-	-	-	-	-	-	-	-	-	-
5/15/2015	Synedra	Diatom	-	-	-	-	L	L	M	M	-	-	-	-	-	-
5/15/2015	Tabellaria	Diatom	-	-	-	-	L	L	L	-	-	-	-	-	-	-
5/15/2015	Unknown filamentous green	Green	-	-	-	-	-	-	-	L	-	-	-	-	-	-
9/22/2015	Achnanthes/Navicula	Diatom	-	-	-	H	-	H	H	H	H	-	M	-	-	-
9/22/2015	Ankistrodesmus	Green	-	-	-	-	-	L	-	-	-	-	L	-	-	-
9/22/2015	Bulbochaete	Green	-	-	-	L	-	L	-	-	-	-	-	-	-	-
9/22/2015	Cocconeis	Diatom	-	-	-	L	-	L	L	L	L	-	L	-	-	-
9/22/2015	Cosmarium	Desmid	-	-	-	-	-	L	-	-	-	-	-	-	-	-
9/22/2015	Crucigenia	Green	-	-	-	L	-	L	L	-	-	-	-	-	-	-
9/22/2015	Cymbella	Diatom	-	-	-	M	-	L	L	-	L	-	M	-	-	-
9/22/2015	Diatoma	Diatom	-	-	-	L	-	-	-	-	-	-	-	-	-	-
9/22/2015	Didymosphenia	Diatom	-	-	-	L	-	L	-	L	-	-	L	-	-	-
9/22/2015	Fragilaria	Diatom	-	-	-	L	-	L	L	L	-	-	L	-	-	-
9/22/2015	Gomphonema	Diatom	-	-	-	L	-	L	L	-	L	-	M	-	-	-
9/22/2015	Melosira	Diatom	-	-	-	-	-	-	-	L	-	-	L	-	-	-
9/22/2015	Merismopedia	Blue-green	-	-	-	-	-	-	L	-	-	-	L	-	-	-
9/22/2015	Oedogonium	Green	-	-	-	-	-	-	-	M	M	-	L	-	-	-
9/22/2015	Oocystis	Green	-	-	-	L	-	-	-	-	-	-	-	-	-	-
9/22/2015	Pediastrum	Green	-	-	-	L	-	-	-	L	-	-	L	-	-	-
9/22/2015	Pediastrum tetras	Green	-	-	-	L	-	L	L	L	-	-	-	-	-	-
9/22/2015	Scenedesmus	Green	-	-	-	M	-	M	M	L	L	-	L	-	-	-

Date	Taxon	Type	45IC02.2	45MC00.1	45PC00.1	45WR01.1	45WR01.8	45WR03.4	45WR07.0	45WR09.5	45WR11.4	45WR15.4	45WR21.3	45WR28.5	45WR35.5	45WR53.5
9/22/2015	Staurastrum	Desmid	-	-	-	L	-	L	L	-	-	-	-	-	-	-
9/22/2015	Synedra	Diatom	-	-	-	L	-	M	L	L	L	-	M	-	-	-
9/22/2015	Ulothrix	Green	-	-	-	-	-	-	-	-	L	-	M	-	-	-
9/22/2015	Unknown (Rivulariaceae)	Blue-green	-	-	-	M	-	-	-	-	M	-	-	-	-	-
9/22/2015	Unknown filamentous green	Green	-	-	-	-	-	-	-	-	-	-	L	-	-	-
9/22/2015	Unknown filamentous sp. 1	-	-	-	-	L	-	-	-	-	M	-	-	-	-	-
9/22/2015	Unknown filamentous sp. 2	-	-	-	-	L	-	-	-	-	L	-	-	-	-	-
9/22/2015	Unknown green unicell	Green	-	-	-	L	-	-	-	-	-	-	-	-	-	-
9/22/2015	Unknown green unicell flagellate	Green	-	-	-	-	-	-	L	-	-	-	-	-	-	-

H: high abundance; M: medium abundance; L: low abundance

Table D-8: PCB and DDT concentrations in invertebrates.

Site ID	Site name	Date	d15N	d13C	%lipids	t-PCBs (pg/g)	t-PCBs (pg/g OC)	t-DDT (pg/g)	t-DDT (pg/g OC)
45WR01.1	Hwy 285 bridge	9/23/2015	8.8	-17.8	4.5	315781.9	115970.7	32242.0	11840.9
45WR07.0	Old Monitor	9/23/2015	8.6	-15.4	3.4	31728.6	13279.2	ns	ns
45WR09.5	Cotlets Way	9/23/2015	8.4	-16.7	4.6	65970.5	23715.8	ns	ns
45WR21.3	Osprey	9/22/2015	8.0	-15.6	3.7	1141.7	531.3	ns	ns

ns: not sampled

Table D-9: Size, age, sex, and stable isotope composition of mountain whitefish.

ID	Sample date	Location	Weight (g)	Length (mm)	Sex	Age	Stomach contents	%N	d15N	%OC	d13C	C:N (molar)	Sample
MWF-1a	5/18/2015	confluence	261	315	M	3	-	12.7	11.7	45.6	-22.5	4.2	whole
MWF-2a	5/18/2015	confluence	248	312	F	3	-	-	-	-	-	-	whole
MWF-3a	5/18/2015	confluence	191	285	M	3	-	13.1	11.9	45.5	-19.5	4.0	whole
MWF-4a	5/18/2015	confluence	413	354	M	7	-	12.5	11.7	45.9	-18.0	4.3	whole
MWF-5a	5/18/2015	confluence	237	295	F	3	-	12.9	11.1	45.9	-16.7	4.2	whole
MWF-6a	5/18/2015	confluence	891	484	F	6	-	13.8	12.3	45.2	-19.0	3.8	whole
MWF-7a	5/18/2015	confluence	169	278	F	2	X	-	-	-	-	-	composite
MWF-8a	5/18/2015	confluence	159	275	F	2	X	-	-	-	-	-	composite
MWF-9a	5/18/2015	confluence	275	323	F	5	X	-	-	-	-	-	composite
MWF-10a	5/18/2015	confluence	251	295	F	3	X	-	-	-	-	-	composite
MWF-11a	5/18/2015	confluence	195	285	M	3	X	-	-	-	-	-	composite
MWF-12a	5/18/2015	confluence	554	389	F	8	X	-	-	-	-	-	composite
MWF-13a	5/18/2015	confluence	425	354	F	7	X	-	-	-	-	-	composite
MWF-14a	5/18/2015	confluence	329	341	F	4	X	-	-	-	-	-	composite
MWF-15a	5/18/2015	confluence	547	397	F	8	X	-	-	-	-	-	composite
MWF-16a	5/18/2015	confluence	325	335	F	4	X	-	-	-	-	-	composite
MWF-17a	5/19/2015	osprey (RM 21)	433	350	F	7	-	13.6	10.5	48.1	-19.2	4.1	whole
MWF-18a	5/19/2015	osprey (RM 21)	391	344	F	5	-	13.1	10.5	48.4	-18.5	4.3	whole
MWF-19a	5/19/2015	osprey (RM 21)	108	242	M	3	-	13.3	10.7	45.7	-16.9	4.0	whole
MWF-20a	5/19/2015	osprey (RM 21)	607	405	F	16	-	12.8	11.6	48.9	-17.7	4.5	whole
MWF-21a	5/20/2015	osprey (RM 21)	497	381	F	7	X	-	-	-	-	-	composite
MWF-22a	5/20/2015	osprey (RM 21)	571	400	F	9	X	-	-	-	-	-	composite
MWF-23a	5/20/2015	osprey (RM 21)	342	344	M	6	X	-	-	-	-	-	composite
MWF-24a	5/20/2015	osprey (RM 21)	495	384	F	6	X	-	-	-	-	-	composite
MWF-1b	9/21/2015	confluence	528	381	F	3	-	13.0	13.1	49.0	-27.4	4.4	whole
MWF-2b	9/21/2015	confluence	351	313	F	2	-	8.6	11.6	62.6	-29.4	8.5	whole
MWF-3b	9/21/2015	confluence	306	356	F	4	-	13.6	11.0	47.9	-17.5	4.1	whole

ID	Sample date	Location	Weight (g)	Length (mm)	Sex	Age	Stomach contents	%N	d[15]N	%OC	d[13]C	C:N (molar)	Sample
MWF-4b	9/21/2015	confluence	128	232	M	2	-	13.2	10.5	49.3	-15.5	4.4	whole
MWF-5b	9/21/2015	confluence	105	228	M	2	-	10.2	10.3	49.2	-17.9	5.6	whole
MWF-6b	9/21/2015	confluence	232	307	F	3	X	13.3	11.3	48.6	-21.2	4.3	whole
MWF-7b	9/21/2015	confluence	202	290	F	2	X	-	-	-	-	-	composite
MWF-8b	9/21/2015	confluence	190	277	M	2	X	-	-	-	-	-	composite
MWF-9b	9/21/2015	confluence	201	279	M	2	X	-	-	-	-	-	composite
MWF-10b	9/21/2015	confluence	315	292	F	3	X	-	-	-	-	-	composite
MWF-11b	9/22/2015	osprey (RM 21)	163	290	F	2	X	-	-	-	-	-	composite
MWF-12b	9/22/2015	osprey (RM 21)	260	313	F	3	X	-	-	-	-	-	composite
MWF-13b	9/22/2015	osprey (RM 21)	182	285	F	2	X	-	-	-	-	-	composite
MWF-14b	9/22/2015	osprey (RM 21)	113	234	F	2	X	-	-	-	-	-	composite
MWF-15b	9/22/2015	osprey (RM 21)	213	286	F	3	X	-	-	-	-	-	composite
MWF-16b	9/22/2015	osprey (RM 21)	297	330	F	5	X	-	-	-	-	-	composite
MWF-17b	9/22/2015	osprey (RM 21)	340	356	M	5	X	-	-	-	-	-	composite
MWF-18b	9/22/2015	osprey (RM 21)	425	370	F	6	X	-	-	-	-	-	composite
MWF-19b	9/22/2015	osprey (RM 21)	418	377	M	6	X	-	-	-	-	-	composite
MWF-20b	9/22/2015	osprey (RM 21)	447	390	M	7	X	-	-	-	-	-	composite
MWF-21b	9/22/2015	osprey (RM 21)	167	277	F	3	-	12.8	9.3	48.7	-18.3	4.4	whole
MWF-22b	9/22/2015	osprey (RM 21)	527	414	F	7	-	12.6	10.0	47.6	-18.3	4.4	whole
MWF-23b	9/22/2015	osprey (RM 21)	236	300	F	3	-	12.9	9.6	47.6	-18.1	4.3	whole
MWF-24b	9/22/2015	osprey (RM 21)	228	312	F	4	-	14.0	12.1	47.4	-21.5	3.9	whole
MWF-25b	9/22/2015	osprey (RM 21)	100	225	M	2	-	13.5	9.8	47.2	-15.6	4.1	whole
MWF-26b	9/22/2015	osprey (RM 21)	453	399	F	7	-	12.8	11.9	51.8	-18.6	4.7	whole

Table D-10: DDT load for the Wenatchee River basin during 2014 and 2015.

Site	Sample date	Harmonic mean Q (L/sec)	t-DDT (pg/L)		t-DDT load (mg/day)
September 2014 (low-flow)					
Mainstem					
45WR07.0*	9/16/2014	21732.8	345.2		648.2
45WR21.3*	9/15/2014	22994.2	107.0		212.5
45WR35.5*	9/17/2014	17068.2	26.6		39.2
45WR53.5*	9/17/2014	12799.5	33.2		36.8
Tributaries					
45WHR8.8*	9/17/2014	9347.4	22.7		18.3
45IC02.2*	9/16/2014	4190.1	29.2		10.6
May 2015 (high-flow)					
Mainstem					
45WR07.0	5/12/2015	111138.1	191.6	J	1840.0
45WR21.3	5/13/2015	118985.6	20.7	UJ	212.4
Tributaries					
45MC00.1	5/13/2015	602.4	5434.8		282.9
45PC00.3	5/13/2015	5116.5	102.6	J	45.3
45IC05.8	5/14/2015	28978.4	11.1	UJ	27.8
45CC00.2	5/14/2015	278.4	7578.4		182.3
Irrigation returns					
45HR00.1	5/12/2015	424.8	941.6		34.6
September 2015 (low-flow)					
Mainstem					
45WR07.0*	9/28/2015	12399.2	1580.1		1692.7
Tributaries					
45MC00.1	9/3/2015	9.9	3838.8		3.3
45PC00.3	9/3/2015	101.5	360.9		3.2
45CC00.2	9/3/2015	22.2	6485.8		12.5

Site	Sample date	Harmonic mean Q (L/sec)	t-DDT (pg/L)		t-DDT load (mg/day)
Irrigation returns					
45HR00.1	9/3/2015	453.1	388.8		15.2

* semi-permeable membrane device
U: analyte not detected above blank
J: result is an estimate

Table D-11: PCB load for the Wenatchee River basin during 2014 and 2015.

Site	Site name	River mile	Harmonic mean Q (L/sec)	t-PCBs (pg/L)		t-PCB load (mg/day)
September 2014 (low-flow)						
45WR07.0	Old Monitor	7	21732.8	343.3		644.5
45WR21.3	Osprey	21.3	22994.2	27.8	U	75.4
45WR35.5	Tumwater	35.5	17068.2	22.9	U	56.0
45WR53.5	Lk Wenatchee	53.5	12799.5	52.0	U	42.0
45WHR8.8	White R	60	9347.4	42.7	U	30.7
Tributaries						
45IC02.2	Icicle	26	4190.1	53.1	U	13.7
September 2015 (low-flow)						
45WR07.0	Old Monitor	7	12399.2	313.0		335.3
45WR21.3	Osprey	21.3	14222.7	48.1		59.2
Tributaries						
45IC02.2	Icicle	26	2275.6	42.6		8.4

Appendix E. Bioaccumulation model parameters

Model parameter	Name	Units	Value		Source
General parameters					
Non-lipid organic matter – octanol proportionality constant	b	Unitless	0.035		Gobas et al., 1999 (SD estimated)
Growth rate factor - fish	GRFF	Unitless	0.000736		Thomann et al., 1992
Growth rate factor - invertebrates	GRFI	Unitless	0.000311		Thomann et al., 1992
Dietary absorption efficiency of lipid - invertebrates	eL	Unitless	0.730798		Arnot and Gobas, 2004
Dietary absorption efficiency of non-lipid organic matter - invertebrates	eN	Unitless	0.775407		Arnot and Gobas, 2004
Dietary absorption efficiency of water - invertebrates	eW	Unitless	0.555492		Arnot and Gobas, 2004
Dietary absorption efficiency of lipid - fish	eL	Unitless	0.964161		Arnot and Gobas, 2004; Kelly et al., 2004
Dietary absorption efficiency of non-lipid organic matter - fish	eN	Unitless	0.462541		Arnot and Gobas, 2004
Dietary absorption efficiency of water - fish	eW	Unitless	0.526267		Arnot and Gobas, 2004
Water and sediment parameters					
Concentration of particulate organic carbon in water	Xpoc	kg/L	8.66E-08		Measured 2014-2015
Concentration of dissolved organic carbon in water	Xdoc	kg/L	4.95E-07		Measured 2014-2015
Concentration of suspended solids	Vss	kg/L	2.08E-06		Measured 2014-2015
Mean annual water temperature	Tw	oC	9.20E+00		Taken from Ambient stations @ Wenatchee and Tumwater Campground for WY14
Mean annual air temperature	Ta	oC	1.11E+01		Based on NOAA climate summary for 2014 averaged between Leavenworth and Wenatchee.
Density of organic carbon in sediment	dOCS	kg/L	9.09E-01		Arnot cites MacKay and Paterson, 1991
Organic carbon content of sediment	OCS	unitless	2.06E-02		Estimated from single sample near the confluence; biased
Dissolved oxygen concentration @ 90% saturation	Cox	mg O2/L	1.08E+01		Estimated from: Pawlowicz et al., 2003
Setschenow proportionality constant	S_PC	L/cm3	0.0018		Xie, WH, Shiu, WY, MacKay, D. 1997.

Model parameter	Name	Units	Value		Source
Primary production rate of organic carbon	PPR	gC/cm2/yr	3.20E-01		Estimated from modeled GPP and ER using the RAV model and then converted to OC using 0.8 (Zimmer et al L&O 2015)
Disequilibrium factor for POC partitioning in water column	Dpoc	unitless	1		Arnot and Gobas 2004 (eqn 4)
Disequilibrium factor for DOC partitioning in water column	Ddoc	unitless	1		Arnot and Gobas 2004 (eqn 4)
Proportionality constant for phase partitioning of POC	alphaPOC	unitless	0.35		Arnot and Gobas 2004 (eqn 4)
Proportionality constant for phase partitioning of POC	alphaDOC	unitless	0.08		Arnot and Gobas 2004 (eqn 4)
Periphyton parameters					
Lipid fraction in plant	vLB	Unitless	0.002295		Measured 2014 and 2015
Non-lipid organic carbon fraction in plant	vNB	Unitless	0.060036		Measured 2014 and 2015
Water fraction in plant	vWB	Unitless	0.937669		Calculated
Growth rate constant	kG	d-1	0.612808		Borchardt, MA. 1996. Nutrients. In: Stevenson, RJ, ML Bothwell and RL Lowe (Eds). 1996. Algal Ecology: Freshwater Benthic Ecosystems. Academic Press, San Diego, CA
Aqueous phase resistance constant	AP	Unitless	6.00E-05		Arnot and Gobas, 2004
Organic phase resistance constant	BP	Unitless	5.5		Arnot and Gobas, 2004
Invertebrate parameters			**Caddisfly**	**Mayfly**	
Wet weight of the organism	WB	kg	1.00E-04	2.05E-05	Estimated from specimen body length
Lipid fraction in biota	vLB	Unitless	6.11E-02	3.67E-02	Measured
Non-lipid organic matter fraction in biota	vNB	Unitless	4.20E-01	3.99E-01	Calculated
Water fraction in biota	vWB	Unitless	0.52	0.56	Mauchline, 1998
ED constant A	EDA	Unitless	8.5E-08	8.5E-08	Arnot and Gobas, 2004
ED constant B	EDB	Unitless	2.00E+00	2.00E+00	Arnot and Gobas, 2004
Carbon fraction of lipids	CfracLB	Unitless	0.75	0.75	Arnot and Gobas, 2004
Carbon fraction of NLOM	CfracNB	Unitless	0.4	0.4	Arnot and Gobas, 2004
Fish parameters					
Wet weight of the organism	WB	kg	3.52E-01		Measured
Lipid fraction in biota	vLB	Unitless	4.76E-02		Measured

Model parameter	Name	Units	Value		Source
Non-lipid organic matter fraction in biota	vNB	Unitless	4.50E-01		Measured
Water fraction in biota	vWB	Unitless	0.5		Derived
Fraction of respiration that involves sediment pore water	mP	Unitless	0		Estimated using fishbase.org
ED constant A	EDA	Unitless	8.5E-08		Arnot and Gobas, 2004
ED constant B	EDB	Unitless	2.00E+00		Arnot and Gobas, 2004
Carbon fraction of lipids	CfracLB	Unitless	0.75		Arnot and Gobas, 2004
Carbon fraction of NLOM	CfracNB	Unitless	0.5		Arnot and Gobas, 2004

Appendix F. Laboratory raw data

Laboratory electronic data deliverable spreadsheets are available as a zip file linked to this report at https://fortress.wa.gov/ecy/publications/SummaryPages/1603029.html

Appendix G. Glossary, acronyms, and abbreviations

Glossary

Clean Water Act: A federal act passed in 1972 that contains provisions to restore and maintain the quality of the nation's waters. Section 303(d) of the Clean Water Act establishes the TMDL program.

Dissolved oxygen (DO): A measure of the amount of oxygen dissolved in water.

Parameter: Water quality constituent being measured (analyte). A physical, chemical, or biological property whose values determine environmental characteristics or behavior.

Partition coefficient: the ratio of chemical concentrations in a mixture at equilibrium of phases that do not mix. The ratio is the difference in solubility. In the environmental sciences, the octonal-water partition coefficient (Kow) is often used to describe the likelihood a particular chemical will dissolve into water.

pH: A measure of the acidity or alkalinity of water. A low pH value (0 to 7) indicates that an acidic condition is present, while a high pH (7 to 14) indicates a basic or alkaline condition. A pH of 7 is considered to be neutral. Since the pH scale is logarithmic, a water sample with a pH of 8 is ten times more basic than one with a pH of 7.

Pollution: Contamination or other alteration of the physical, chemical, or biological properties of any waters of the state. This includes change in temperature, taste, color, turbidity, or odor of the waters. It also includes discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state. This definition assumes that these changes will, or are likely to, create a nuisance or render such waters harmful, detrimental, or injurious to (1) public health, safety, or welfare, or (2) domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or (3) livestock, wild animals, birds, fish, or other aquatic life.

Salmonid: Fish that belong to the family *Salmonidae*. Species of salmon, trout, or char.

Stormwater: The portion of precipitation that does not naturally percolate into the ground or evaporate but instead runs off roads, pavement, and roofs during rainfall or snow melt. Stormwater can also come from hard or saturated grass surfaces such as lawns, pastures, playfields, and from gravel roads and parking lots.

Total Maximum Daily Load (TMDL): Water cleanup plan. A distribution of a substance in a waterbody designed to protect it from not meeting (exceeding) water quality standards. A TMDL is equal to the sum of all of the following: (1) individual wasteload allocations for point sources, (2) the load allocations for nonpoint sources, (3) the contribution of natural sources, and (4) a Margin of Safety to allow for uncertainty in the wasteload determination. A reserve for future growth is also generally provided.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

303(d) list: Section 303(d) of the federal Clean Water Act requires Washington State to periodically prepare a list of all surface waters in the state for which beneficial uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality-limited estuaries, lakes, and streams that fall short of state surface water quality standards and are not expected to improve within the next two years.

Acronyms and Abbreviations

BAF	Bioaccumulation Factors
BCF	Bioconcentration Factor
CLAMs	Continuous Low-Level Aquatic Monitoring Devices
DDD	Dichloro-Diphenyl-Dichloroethane
DDE	Dichloro-Diphenyl-Dichloroethylene
DDT	Dichloro-Diphenyl-Trichloroethane
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
EST	Environmental Sampling Technologies
FC	Fecal coliform bacteria
FTEC	Fish Tissue Equivalent Concentration
HUC	Hydrologic Unit Code
ISIS	Integrated Site Information System
MDL	Method Detection Limits
MEL	Manchester Environmental Laboratory
MQL	Method Quantitation Limit
MWF	Mountain Whitefish
NTR	National Toxics Rule
OC	Organic Carbon
OM	Organic Matter
PCB	Polychlorinated Biphenyls
POTW	Publicly Owned Treatment Works
PRC	Performance Reference Compounds
QA/QC	Quality Assurance/Quality Control
RM	River Mile
RPD	Relative Percent Difference
RSD	Relative Standard Deviation
SOP	Standard Operating Procedures
SPE	Solid-Phase Extraction
SPMD	Semi-Permeable Membrane Devices
TEQ	Toxic Equivalence
TMDL	(See Glossary above)
TOC	Total Organic Carbon
TSS	Total Suspended Solids
USGS	U.S. Geological Survey
WAC	Washington Administrative Code

WRIA	Water Resource Inventory Area
WSDA	Washington State Department of Agriculture

Units of Measurement

‰	per mil (part per thousand)
cfs	cubic feet per second
g	gram, a unit of mass
kg	kilograms, a unit of mass equal to 1,000 grams
L/s	liters per second
m	meter
mg	milligram
mg/day	milligrams per day
ng/g	nanograms per gram (parts per billion)
ng/L	nanograms per liter (parts per trillion)
pg/g	picograms per gram (parts per trillion)
pg/L	picograms per liter (parts per quadrillion)
pg/S	picograms per sample (SPMD)
ug/Kg	micrograms per kilogram (parts per billion)