WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Mission Creek Watershed DDT Total Maximum Daily Load

Water Quality Improvement Report

July 2007
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Water Quality Program

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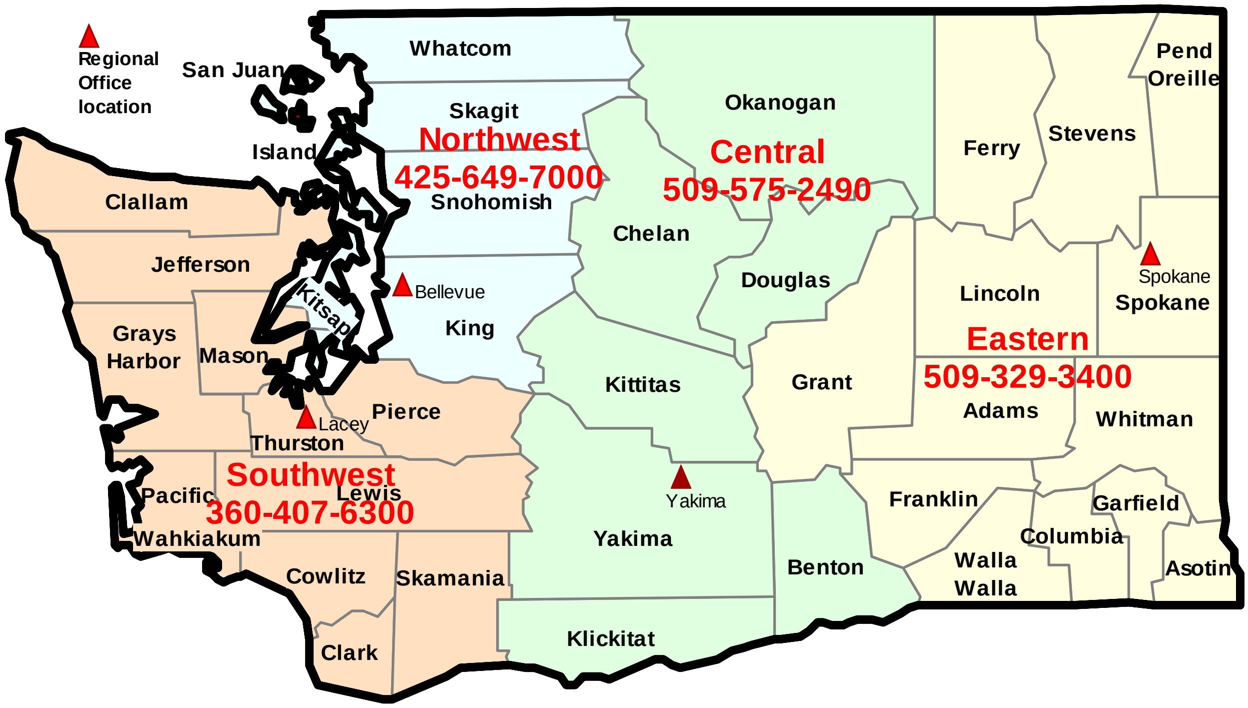

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Executive Summary

The federal Clean Water Act requires that a total maximum daily load (TMDL) be developed for each of the waterbodies on the 303(d) list. The TMDL identifies pollution problems in the watershed, and then specifies how much pollution needs to be reduced or eliminated to achieve clean water. The Washington State Department of Ecology (Ecology) then works with the local community to develop, (1) an overall approach to control the pollution, called the summary implementation strategy, and (2) a monitoring plan to assess the effectiveness of the water quality improvement activities.

Ecology conducted this TMDL in order to set targets that, if achieved, will bring 303(d) listed streams in the Mission Creek watershed into compliance with state water quality standards. Table ES-1 shows the 303(d) listed streams in the watershed addressed by this TMDL.

Table ES-1: 303(d) Listings in the Mission Creek Watershed addressed by this TMDL.

Waterbody	Parameter	Medium	Listing ID	Township	Range	Section
Mission Creek	4,4'-DDD	Water	34832	23N	19E	04
Mission Creek	4,4'-DDE	Water	34826	23N	14E	04
Mission Creek	4,4'-DDE	Fish Tissue	8960	23N	19E	04
Mission Creek	4,4'-DDT	Water	34829	23N	19E	04
Mission Creek	4,4'-DDT	Water	8958	23N	19E	04
Mission Creek	4,4'-DDT	Fish Tissue	8959	23N	19E	04
Brender Creek	4,4'-DDD	Water	34833	23N	19E	05
Brender Creek	4,4'-DDE	Water	34827	23N	19E	05
Brender Creek	4,4'-DDT	Water	34830	23N	19E	05
Yaksum Creek	4,4'-DDD	Water	34834	23N	19E	09
Yaksum Creek	4,4'-DDE	Water	34828	23N	19E	09
Yaksum Creek	4,4'-DDT	Water	34831	23N	19E	09

The Mission Creek watershed is in Water Resource Inventory Area (WRIA) 45 which is also known as the Wenatchee River watershed. The watershed is in Chelan County in central Washington State. The Mission Creek watershed drains 93.3 square miles (59,712 acres), from the Wenatchee National Forest uplands to the Wenatchee River at the city of Cashmere, Washington.

Brender Creek, Yaksum Creek, and No Name Creek are tributaries to Mission Creek. The climate is characterized by mild to severe winters with hot, dry summers. Streams in the watershed have high flows following snowmelt in the spring and early summer.

The water quality standard for DDT and DDE in water is 0.59 ng/l and is 0.83 ng/l for DDD. One ng/l equals one part per trillion (ppt). The study found that total-DDT concentrations in filtered and unfiltered surface water ranged from 0.1 ng/l to 130 ng/l t-DDT at all sites except in Mission Creek above the Wenatchee National Forest boundary.

The highest t-DDT concentrations were found in lower Yaksum Creek. In order to meet water quality standards, load reductions of t-DDT need to meet the targets presented in table ES-2.

Table ES-2: t-DDT load reductions presented by this TMDL

Stream/Location	Harmonic Mean Discharge (l/s)	t-DDT Criterion (ng/l)	Target Load (mg/d)	Average t-DDT (ng/l)	Current Load (mg/d)	Load Reduction (mg/d)	Load Reduction (%)
Mission Creek – 2MC	138	1	12	3.2	38	26	69
Mission Creek – MISSPZ1	97	1	8.4	0.4	3.4	(5.0)	(150)
Brender Creek – 3MC	86	1	7.4	11	84	77	91
Brender Creek – BRENPZ1	37	1	3.2	26	83	80	96
Yaksum Creek – near mouth	18	1	1.6	62	96	94	98

( ) = reserve capacity

The TMDL recommendations will be carried out through existing requirements and programs, as well as voluntary measures to reduce soil erosion in Mission Creek watershed and education. Monitoring will measure progress toward water quality goals. A water quality implementation plan will be developed within a year after the United States Environmental Protection Agency approves this TMDL.

Acknowledgements

Many thanks to the participants on the Wenatchee Water Quality Technical Subcommittee and Wenatchee Watershed Planning Unit for their ongoing participation, technical support, wise suggestions, dedication, and commitment to improving water quality and the environment. The Mission Creek Watershed DDT TMDL was developed through the participation and input of numerous stakeholders from the Wenatchee Watershed over several years, many of whom spent countless hours providing information, reviewing and formulating plan actions, and attending meetings to represent their constituencies.

Introduction

The Clean Water Act established a process to identify and clean up polluted waters. Under the Clean Water Act, each state is required to have its own water quality standards designed to protect, restore, and preserve water quality. Water quality standards consist of designated uses for protection, such as cold water biota and drinking water supply, as well as criteria (usually numeric criteria) to achieve those uses.

Every two years, states are required to prepare a list of waterbodies – lakes, rivers, streams, or marine waters – that do not meet water quality standards. This list is called the 303(d) list. To develop the list, the Department of Ecology (Ecology) compiles its own water quality data along with data submitted by local, state, and federal governments, tribes, industries, and citizen monitoring groups. All data are reviewed to ensure that they were collected using appropriate scientific methods before it is used to develop the 303(d) list. The 303(d) list is part of the larger Water Quality Assessment.

The Water Quality Assessment is a list that tells a more complete story about the condition of Washington's water. This list divides waterbodies into one of five categories:

Category 1 – Meets standards for parameter(s) for which it has been tested

Category 2 – Waters of concern

Category 3 – Waters with no data available

Category 4 – Polluted waters that do not require a Total Maximum Daily Load (TMDL) because:

- 4a. – Has a TMDL approved and it is being implemented
- 4b. – Has a pollution control program in place that should solve the problem
- 4c. – Is impaired by a non-pollutant such as low water flow, dams, culverts

Category 5 – Polluted waters that require a TMDL – the 303d list.

Washington's 303(d) list consists of those waterbodies that fall into Category 5 in the Water Quality Assessment process.

TMDL Process Overview

The Clean Water Act requires that a TMDL be developed for each of the waterbodies on the 303(d) list. The TMDL identifies pollution problems in the watershed and then specifies how much pollution needs to be reduced or eliminated to achieve clean water. Then Ecology works with the local community to develop an overall approach to control the pollution, called the summary implementation strategy, and a monitoring plan to assess effectiveness of the water quality improvement activities. Once the United States Environmental Protection Agency (EPA) approves the TMDL, a w*ater quality implementation plan* (WQIP) should be developed within one year. The WQIP identifies specific tasks, responsible parties and timelines for achieving clean water.

This TMDL submittal is based on work presented in *DDT Contamination and Transport in the Lower Mission Creek Basin, Chelan County* (Serdar and Era Miller, 2004) which will be referred to as the technical report.

Elements required in a TMDL

The goal of a TMDL is to ensure the impaired water will attain water quality standards. A TMDL includes a written, quantitative assessment of water quality problems and of the pollutant sources that cause the problem. The TMDL determines the amount of a given pollutant that can be discharged to the waterbody and still meet standards (the loading capacity) and allocates that load among the various sources. This allocation was published in the technical report. The Wenatchee Watershed Planning Unit's (WWPU) Water Quality Technical Subcommittee (WQTS) reviewed the technical report twice.

If the pollutant comes from a discrete source (referred to as a point source) such as a municipal or industrial facility's discharge pipe, that facility's share of the loading capacity is called a *wasteload allocation*. If the pollutant comes from a diffuse source (referred to as a nonpoint source) such as urban, residential or farm runoff, the cumulative share of diffuse source inputs is called a *load allocation*.

The TMDL must also consider seasonal variations and include a margin of safety that takes into account any lack of knowledge about the causes of the water quality problem or its loading capacity. A reserve capacity for future loads from growth pressures may be included. The sum of the wasteload and load allocations, the margin of safety, and any reserve capacity must be equal to or less than the loading capacity.

Identifying the contaminant loading capacity for a waterbody is an important step in developing a TMDL. EPA defines the loading capacity as "the greatest amount of loading that a waterbody can receive without violating water quality standards" (EPA, 2001). The loading capacity provides a reference for calculating the amount of pollution reduction needed to bring a waterbody into compliance with standards. The portion of the receiving water's loading capacity assigned to a particular source is a load allocation (LA) or wasteload allocation (WLA). By definition, a TMDL is the sum of the allocations, which must not exceed the loading capacity.

TMDL = loading capacity = sum of all WLAs + sum of all LAs + margin of safety
This TMDL does not present WLAs because there are no point sources in the Mission Creek watershed that contribute dichloro-diphenyl-trichloroethane (4,4'-DDT) or its breakdown products, dichloro-diphenyl-dichloroethane (4,4'-DDD) and dichlor-diphenyl-ethane (4,4'-DDE).

In this TMDL, 4,4'-DDT, 4,4'-DDD, and 4,4'-DDE are referred to as DDT, DDD, and DDE. The result of adding the concentrations of DDT, DDD, and DDE is referred to as total DDT (t-DDT).

Background

The Mission Creek watershed is located within the Wenatchee River watershed (WRIA 45) in Chelan County near the central part of the state of Washington (State). The Mission Creek watershed drains 93.3 square miles (59,712 acres), from the Wenatchee National Forest uplands to the Wenatchee River at the city of Cashmere. Figure 1 presents a map of the watershed.

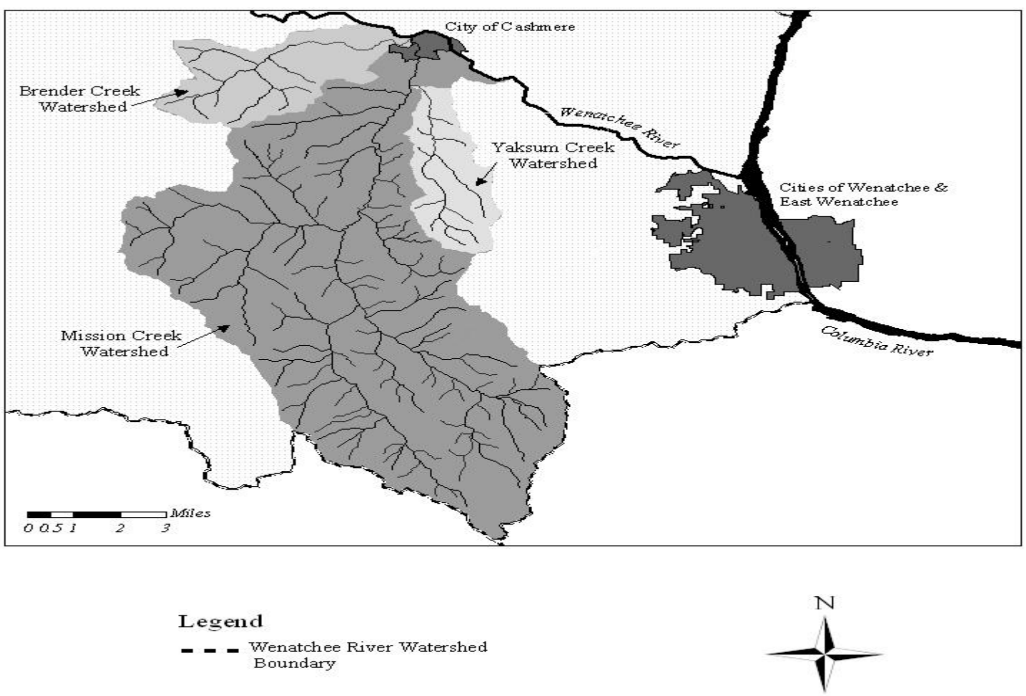

Figure 1: Map of the Mission Creek Watershed including Yaksum Creek and Brender Creek

Brender Creek, Yaksum Creek, and No Name Creek are tributaries to Mission Creek. The climate is characterized by mild to severe winters with hot, dry summers. Streams in the watershed have high flows following snowmelt in the spring and early summer. Flows naturally decline to minimums during the late summer and fall. During the summer critical season, stream flows dry up downstream from some irrigation diversions used during the critical season. Figure 2 presents stream flow data for Mission Creek at Cashmere from 1996 through 2004.

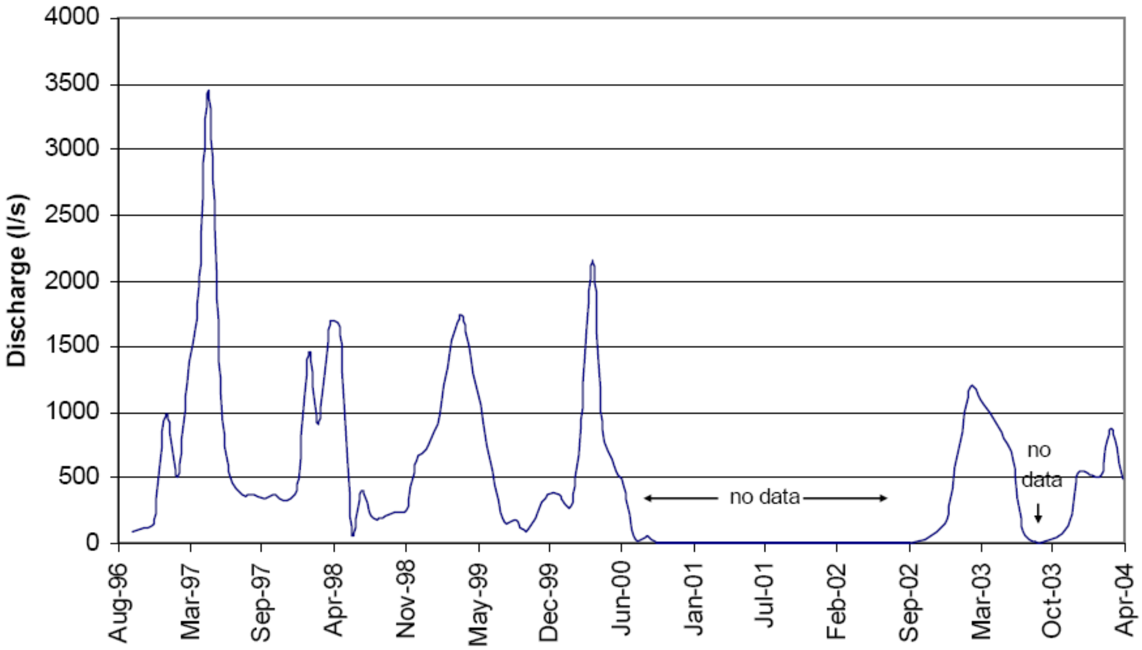

Figure 2: Stream flow in Liters/Second (l/s) for Mission Creek at Cashmere.

The Wenatchee River Watershed Action Plan (WRWAP 1998) notes that soils in the valley bottoms differ significantly among Mission Creek (gravelly), Yaksum Creek (loamy sand to sandy loam), and Brender Creek (clayey, silty, and sandy loams). The WRWAP identified Mission Creek as the most polluted waterbody in the watershed.

Outside of forested lands, pear and apple orchards make up the primary land use in the watershed along with some alfalfa and non-commercial farms. Orchards flank Mission Creek in a narrow band from the urban boundary of Cashmere to near the Wenatchee National Forest boundary. Orchards grow in the lower portion of Yaksum Creek within the confines of the valley that are cultivatable. Orchards are also located in the Brender Creek canyon and are more extensive where the valley broadens on the west side of Cashmere.

DDT was used in Mission Creek Watershed orchards to control coddling moths and other pests from the 1940s to 1970s. EPA banned DDT in 1972. DDT attaches to sediments and particulate matter in the aquatic environment because of its low water solubility and high affinity for solids, especially solids with high organic carbon content. Transport of DDT to streams and movement within aquatic environments is often associated with erosion of contaminated soils and elevated loads of suspended solids (Johnson et al., 1988; Joy and Patterson, 1997). DDT and its breakdown products continue to be present at relatively high concentrations in the streams of the lower Mission Creek Watershed. Since DDT can remain stable for decades when bound to soils (Harris et al., 2000), it is likely that orchard soils are the major source.

Applicable water quality criteria

The state of Washington's water quality standards for surface waters of the state are set in Chapter 173-201A of the Washington Administrative Code (WAC).

Chapter 173-201A-240 WAC includes a provision that "Toxic substances shall not be introduced above natural background levels in waters of the state which have the potential either singularly or cumulatively to adversely affect characteristic water uses, cause acute or chronic toxicity to the most sensitive biota dependent upon those waters or adversely affect public health as determined by the department." Numeric criteria to protect aquatic life from DDT exposure are set to protect the most sensitive aquatic species (EPA, 1980). The chronic criterion for DDT is 1 nanongram per liter (ng/l) – a concentration not to be exceeded as a 24-hour average (Table 1). One ng/l equals one part per trillion (ppt). The acute criterion – not to be exceeded at any time – is three orders of magnitude higher at 1,100 ng/l.

Table 1: Water quality criteria to protect aquatic life and human health from DDT and its breakdown products.

Parameter	Aquatic Life – Chronic[a] (ng/l)	Aquatic Life – Acute[b] (ng/l)	Human Health – Fish Tissue (ng/g)[c]	Human Health[d] – Water and Organisms (ng/l)
4,4'-DDE	1	1,100	32	0.59
4,4'-DDD	1	1,100	45	0.83
4,4'-DDT	1	1,100	32	0.59
t-DDT	1	1,100	ne	ne

[a]Not to be exceeded as a 24-hour average
[b]Not to be exceeded at any time
[c]ng/g = nanograms per gram, equal to parts per trillion in fish tissue
[d]For consumption of organisms and water
ne = not established

Human health criteria

Criteria for the protection of human health are applied to the state through a federal rule [40 CFR 131.36(14)]. In fresh waters, human health criteria take into account the combined exposure of both drinking the water and eating fish that lived in the water. In marine waters, human health criteria only consider the effect of eating fish that lived in the water. The state established criteria to protect against non-carcinogenic illness and to keep the risk of developing cancer to a pre-specified level. In Washington, the cancer risk is set such that no more than 1 in 1,000,0000 people with full exposure would be likely to develop cancer in response to that exposure. Full exposure is defined by set assumptions on body size, fish, and water consumption, and the number of years exposed. For example, in Washington the risk is correlated to an average-sized man consuming 6.5 grams per day of fish (approximately 5 pounds per year), drinking 2 liters of water (if a fresh waterbody), and continuing this pattern for 70 years. People with higher or lower exposure patterns would face higher or lower risks. This basic exposure pattern is the same for both cancer-causing and non-cancer-causing chemicals.

In 1992, the EPA published the National Toxics Rule (NTR, 40 CFR 131.36) which set numeric, chemical-specific water quality criteria for priority pollutants in order to bring states into compliance with the Clean Water Act.

Acceptable fish tissue concentrations are 32 nanograms per gram (ng/g) for DDE and DDT, and 45 ng/g for DDD. One ng/g is equal to one part per billion (ppb). The NTR uses a bioconcentration factor of 53,600 (EPA, 1980) to translate the acceptable tissue concentrations into criteria for water (the tissue concentration times the bioconcentration factor equals the water quality criterion) – 0.59 ng/l for DDE and DDT, and 0.83 ng/l for DDD.

Water quality and resource impairments

Table 2 shows the 303(d) listings for DDT, DDD, and DDE in the Mission Creek watershed. The current (2002/2004) listings are for exceedances of the human health criteria of DDT compounds (DDE, DDT, and DDD).

Table 2: Mission Creek watershed waterbodies on the 2004 303(d) list for DDT, DDE, and DDD.

Waterbody	Parameter	Medium	Listing ID	Township	Range	Section
Mission Creek	4,4'-DDD	Water	34832	23N	19E	04
Mission Creek	4,4'-DDE	Water	34826	23N	14E	04
Mission Creek	4,4'-DDE	Fish Tissue	8960	23N	19E	04
Mission Creek	4,4'-DDT	Water	34829	23N	19E	04
Mission Creek	4,4'-DDT	Water	8958	23N	19E	04
Mission Creek	4,4'-DDT	Fish Tissue	8959	23N	19E	04
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Brender Creek	4,4'-DDE	Water	34827	23N	19E	05
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Yaksum Creek	4,4'-DDD	Water	34834	23N	19E	09
Yaksum Creek	4,4'-DDE	Water	34828	23N	19E	09
Yaksum Creek	4,4'-DDT	Water	34831	23N	19E	09

The technical report (Appendix A) presents data on DDE, DDD, and DDT as individual contaminants. Each of these contaminants exhibits similar chemical and toxic properties. Implementation actions to address each individual contaminant will be the same. For this reason, implementation of this TMDL addresses the contaminants as t-DDT.

Seasonal variation

This TMDL report considers seasonal variation by using calculated loads from pooled 2000-2003 flow data collected over three seasons. Current loads calculated from these data are considered representative of seasonally-adjusted average flow conditions since they were collected under flow regimes ± 25 percent of average.

Stormwater

Currently, no municipalities are permitted to discharge stormwater by the Phase I or Phase II municipal stormwater permit. Stormwater from urban and rural areas in the project area is considered a nonpermitted, nonpoint source of potential pollution. Activities covered by the state's construction or industrial stormwater permits should comply with practices identified in the Eastern Washington stormwater manual (Ecology, 2004).

Data were not collected during rainfall events. Stormwater events may cause episodic loading of t-DDT. By setting daily TMDL targets to meet human health criteria for chronic exposure on a daily basis, it is assumed that the acute criteria will also be met. Water column concentrations measured during the present and previous studies were one to three orders of magnitude less than the acute water quality criterion. Ecology recommends that the implementation plan should include a characterization of t-DDT in stormwater discharge into surface water.

Technical Analysis

Study design

Ecology collected samples in April through June 2003. The Quality Assurance Project Plan for this project (Serdar and Era-Miller, 2003) describes the sampling and analysis plan designed to meet the project objectives. The following various types of samples were collected to assess transport of t-DDT to streams and to assess movement of t-DDT in the streams.

- Upland soils were analyzed to assess whether t-DDT is sequestered at significant concentrations in representative orchard lands and public areas such as schools and city parks.
- Bed sediments were collected from depositional areas to assess the degree to which sediments act as an aquatic sink for t-DDT.
- Suspended particulate matter (SPM) was analyzed for t-DDT to assess the proportion of water column concentrations and loads contained in the solid phase.
- Filtered and unfiltered water column samples were collected from the creeks to assess the influence of the solid and dissolved component.
- Shallow groundwater was sampled to assess it as a potential t-DDT transport mechanism.

Although the study design included plans to collect stormwater runoff to assess transport of upland soils to streams, these samples were never obtained due to logistical problems and a drier than normal spring (precipitation was 30 percent below normal during the 3-month study period).

Sample locations

Ecology selected stream sample locations (Figure 3) based on the type of data desired. Project field staff collected water samples and SPM at stream mouths to assess the total loading and at groundwater sampling locations to assess similarity between surface water and groundwater. Staff also collected groundwater samples based on availability of groundwater in piezometers. Staff collected bed sediments where fine depositional material was available. Accessibility was a factor in selecting all sampling locations.

Field staff collected upland soil samples from five orchards each in the Mission Creek watershed and Yaksum Creek watershed, and from three orchards in the Brender Creek watershed. To decide which orchards to sample, staff gathered lists of addresses on road segments running alongside orchards. A list of parcel owners provided by the Chelan County Assessor's Office was then cross-matched against these addresses. Parcel owners were telephoned in a sequence designed to avoid collecting samples on consecutive parcels. Landowners were informed of the study and asked for permission to sample. If permission was granted, staff asked landowners about the history of the parcels. Parcels that did not have orchards between the early 1950s and mid-1960s were eliminated from consideration as were parcels that had undergone major soil disturbance or conversion to other land uses. Locations are not shown in order to preserve the anonymity of private land owners.

Upland soils were also collected from five public spaces: three ball fields, and two small city parks (Figure 4). Sites were selected following consultation with the Cashmere School District and the City of Cashmere to ensure soils were native or had been relatively undisturbed in the previous 50 years, and that the land had not been used as orchards or for other agriculture in the previous 50 years.

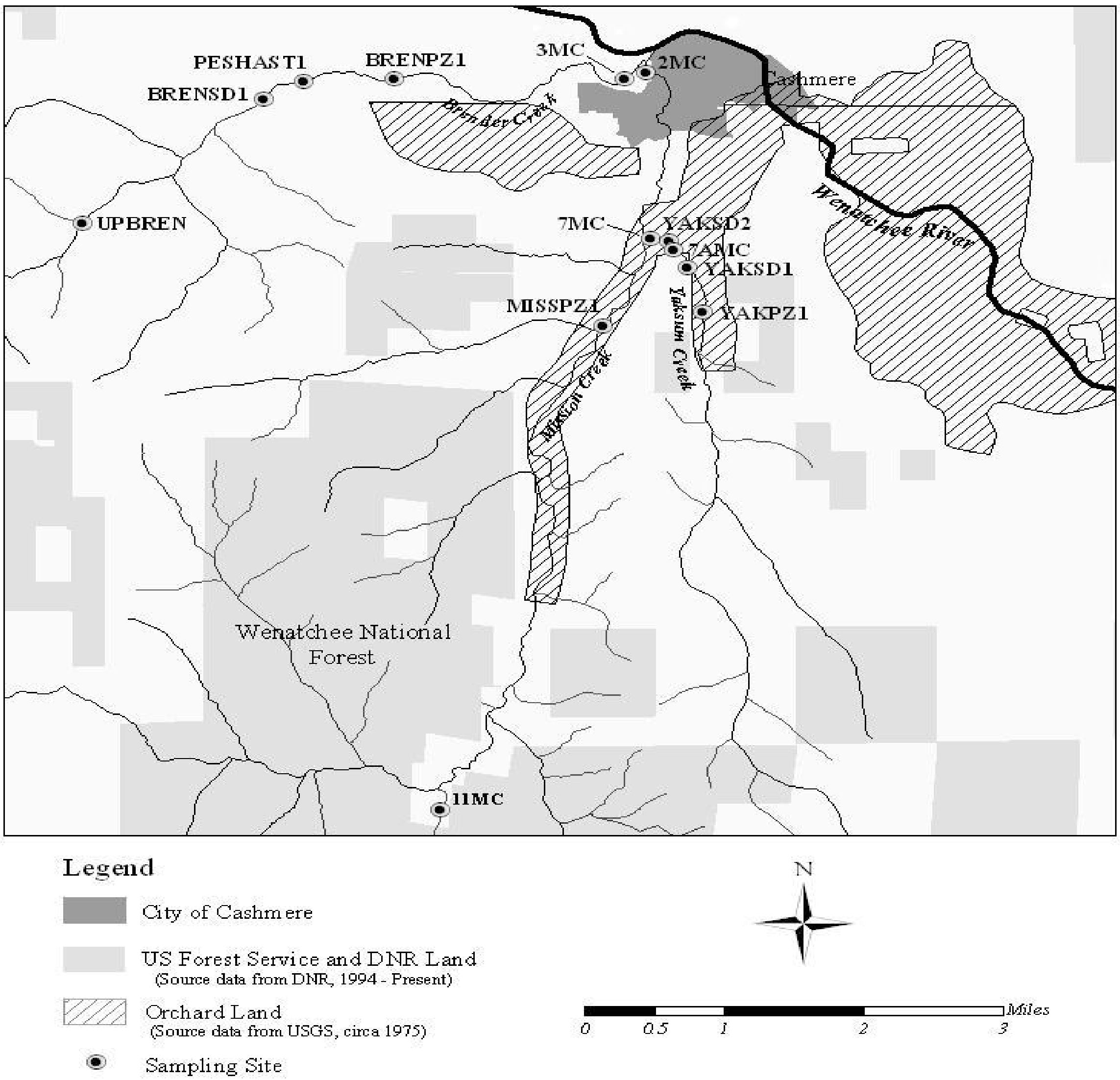

Figure 3: Map of the project area with sampling locations for surface water and sediment sample site locations

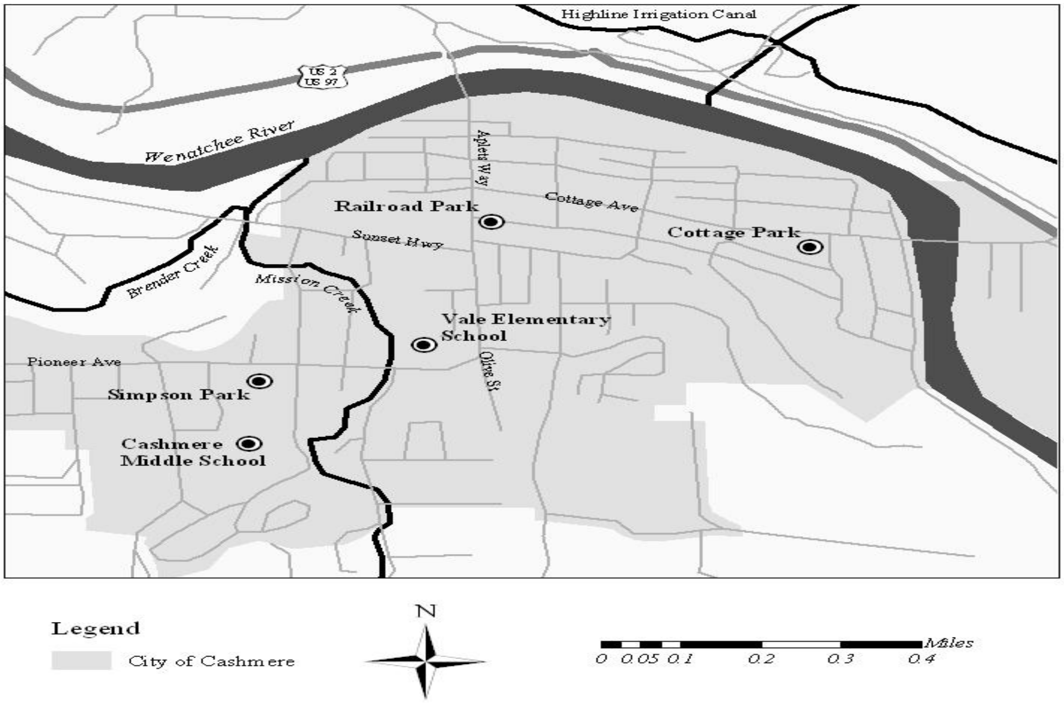

Figure 4: Soil sampling site locations for the technical report.

Data analysis

Statistical analysis was conducted using SYSTAT® 9.01 (SPSS, Inc.). A complete discussion of the statistical analysis can be read in the technical report (Appendix A).

Instantaneous loads of t-DDT were calculated using the following equation.

$$\text{instantaneous load (mg/day)} = IC_w \times (10^{-6}\ \text{mg/ng}) \times IQ\ (86{,}400\ \text{s/day})$$

Where:

- IC_w = instantaneous concentration of t-DDT in unfiltered water (ng/l)
- IQ = instantaneous discharge in l/s.
- mg/day = milligrams per day
- mg/ng = milligrams per nanograms
- s/day = seconds per day

Results

Appendix A presents a complete analsis and the results for all parameters investigated as part of this project.

DDT concentrations in surface water and shallow ground water

Most of the conventional water quality parameters measured during the study appeared to fall into the range of usual values for the streams assessed compared to previous studies. Total organic carbon (TOC) concentrations were similar to those previously reported by Serdar and Era-Miller (2002). Based on differences between paired unfiltered water and filtered samples, most of the TOC is dissolved at each location.

Flows in Mission Creek were typical for the seasons; however, Brender and Yaksum creeks had flows substantially below normal (WRWSC, 1998; Serdar and Era-Miller, 2002). The April 10, 2003, Yaksum Creek discharge measurement may underestimate actual conditions but very low water levels made it difficult to obtain accurate measurements.

DDT concentrations in unfiltered and filtered surface water ranged from 0.1 to 130 ng/l t-DDT, except at Mission Creek above the Wenatchee National Forest boundary (sample location 11MC, Figure 3), where no DDT was detected (Table 4).

- The highest DDT concentrations in surface water were from the lower Yaksum Creek sites (7AMC and 7MC). t-DDT in unfiltered water across sites were composed of 54 percent 4,4'-DDE, 30 percent 4,4'-DDT, and 16 percent 4,4'-DDD on average.

In Yaksum Creek, t-DDT concentrations increased markedly – up to an order of magnitude – downstream of sample locationYAKPZ1. Results also suggest that Yaksum Creek entrains substantial particle-bound DDT in the relatively short reach between 7AMC and 7MC, although there are no paired samples to support this.

t-DDT concentrations in Mission Creek show an increase between MISSPZ1 and 2MC (Figure 3). The confluence of Yaksum Creek and Mission Creek, which is located between MISSPZ1 and 2MC, probably accounts for the increased t-DDT concentrations between these sites.

Brender Creek t-DDT concentrations were intermediate with respect to Yaksum and Mission creeks. Unlike the other streams, however, t-DDT concentrations in Brender Creek decreased between the upstream (BRENPZ1) and downstream (3MC) stations. The Peshastin irrigation spill sampled upstream of BRENPZ1 had a t-DDT concentration an order of magnitude lower than unfiltered water at BRENPZ1.

The BRENPZ1 t-DDT composition was similar to other sites, but unfiltered water from 3MC had an unusual "fingerprint" composed of much higher 4,4'-DDD concentrations compared to other sites (31 percent versus 14 percent). Aside from one sediment sample in Yaksum Creek, the only other samples collected for this study with the "high 4,4'-DDD fingerprint" were bottom sediments and SPM from 3MC.

Approximately 20 to 80 percent of t-DDT was in the dissolved form, based on results of paired unfiltered water and filtered water samples. Mission Creek (2MC) paired samples indicate that 25 percent of the t-DDT was in the dissolved phase, which agrees well with the calculated dissolved fraction from the SPM sample (28 percent). In Brender Creek, however, dissolved t-DDT fractions calculated from paired sample analysis was in poor agreement with SPM (73 percent and 0 percent, respectively). The high dissolved fraction was probably due to poor total suspended solids (TSS) removal efficiency by the centrifuge used for Brender Creek.

No DDT was detected in groundwater samples collected from the Mission and Yaksum Creek sub-basins, suggesting that DDT is not traveling through groundwater in either gaining (Yaksum) or losing (Mission) reaches. However, the groundwater sampling for this project was limited and may not represent all potential groundwater pathways in the lower Mission Creek basin. Information obtained after sampling shows that there is a large groundwater input to Brender Creek in reach river mile (RM) 1.1-1.5. Absent any significant DDT load from groundwater, this input could account for the dilution in DDT concentrations between BRENPZ1 and 3MC. This reach was not sampled during the present study but should be considered for sampling in any subsequent surveys of DDT in groundwater.

Table 3 shows conventional parameters in surface water and shallow groundwater. DDT results are presented in Table 4.

Table 3: Conventional parameters in surface water and shallow ground water.

Location	Sample Type	Date	Discharge (l/s)	TSS (mg/l)		SS (ml/l/hr)		TDS (mg/l)		TOC (mg/l)
Mission Creek										
2MC	Unfiltered water	4/9-10/03	**1,048**	**18**		0.4	U	n/a		**2.4**
"	"	5/29/03	**920**	**19**		0.4	U	n/a		**1.4**
"	"	6/24/03	**328**	**4**		0.1	UJ	n/a		**1.4**
2MC	Filtered water	4/9-10/03	**1,048**	n/a		n/a		**148**		**2.4**
"	"	6/24/03	**328**	1	U	n/a		**138**		**2.4**
MISSPZ1	Unfiltered water	5/29/03	n/a	**11**		0.4	U	n/a		**1.5**
"	"	6/24/03	n/a	**3**		0.1	UJ	n/a		**1.3**
MISSPZ1	Ground water	5/29/03	n/a	**3**		n/a		**240**	J	**1.1**
"	"	6/24/03	n/a	**1**		n/a		**225**		**1.5**

Table 3: (cont) Conventional parameters in surface water and shallow ground water.

Location	Sample Type	Date	Discharge (l/s)	TSS (mg/l)		SS (ml/l/hr)		TDS (mg/l)		TOC (mg/l)
11MC	Unfiltered water	5/28/03	**681**	**7**		0.4	U	n/a		**1.1**
"	"	6/24/03	**246**	**2**		0.1	UJ	n/a		**1.1**
Brender Creek										
3MC	Unfiltered water	4/9-10/03	**67**	**16**		0.4	U	n/a		**2.6**
"	"	5/29/03	**68**	**18**		0.4	U	n/a		**1.8**
"	"	6/24/03	**131**	**4**		0.1	UJ	n/a		**1.5**
3MC	Filtered water	4/9-10/03	**67**	n/a		n/a		**312**		**2.3**
"	"	6/24/03	**131**	1	U	n/a		**195**		**2.6**
BRENPZ1	Unfiltered water	5/29/03	n/a	**36**		0.4	U	n/a		**2.2**
"	"	6/24/03	n/a	**22**		**0.1**	J	n/a		**1.8**
Peshastin Canal										
PESHAST1	Unfiltered water	6/25/03	n/a	n/a		n/a		n/a		n/a
Yaksum Creek										
7AMC	Unfiltered water	4/10/03	**0.2**	1	U	0.4	U	n/a		**2.5**
"	"	" (rep)	**0.2**	**1**		0.4	U	n/a		**2.6**
"	"	6/24/03	**16**	**14**		0.1	UJ	n/a		**1.8**
"	"	" (rep)	**16**	**15**		**0.1**	J	n/a		**1.6**
7AMC	Filtered water	4/10/03	**0.2**	n/a		n/a		**360**		**2.3**
	"	6/24/03	**16**	**1**		n/a		**82**		**3.3**
7MC	Unfiltered water	5/28/03	**16**	**47**		0.4	U	n/a		**2.4**
"	"	" (rep)	**16**	**45**		0.4	U	n/a		**2.2**
Location	**Sample Type**	**Date**	**Discharge (l/s)**	**TSS (mg/l)**		**SS (ml/l/hr)**		**TDS (mg/l)**		**TOC (mg/l)**
YAKPZ1	Unfiltered water	5/29/03	n/a	**4**		0.4	U	n/a		**2.0**
"	"	6/24/03	n/a	**2**		0.1	UJ	n/a		**1.6**
YAKPZ1	Ground water	5/29/03	n/a	**8**		n/a		**308**	J	**1.5**
"	"	6/24/03	n/a	**3**		n/a		**311**		**1.5**

Notes:
Detected values in **bold**
l/s = liters per second
J = estimated concentration
U = undetected at concentration shown
UJ = undetected at estimated concentration shown
n/a = not analyzed

Table 4: Concentrations of DDT (ng/l) in surface water and shallow ground water.

Location	Sample Type	Date	4,4'-DDE		4,4'-DDD		4,4'-DDT		t-DDT
Mission Creek									
2MC	Unfiltered water	4/9-10/03	**0.3**	J	0.3	U	**0.1**	J	**0.4**
"	"	5/29/03	**1.3**		**0.2**	J	**0.9**		**2.4**
"	"	6/24/03	**1.6**		**0.5**		**1.1**	J	**3.2**
2MC	Filtered water	4/9-10/03	**0.1**	J	0.3	U	0.5	U	**0.1**
"	"	6/24/03	**0.3**	J	0.3	UJ	**0.3**	NJ	**0.6**
MISSPZ1	Unfiltered water	5/29/03	**0.3**	J	0.3	U	**0.1**	JB	**0.4**
"	"	6/24/03	**0.4**		0.3	U	**0.2**	J	**0.5**
MISSPZ1	Ground water	5/29/03	0.3	U	0.3	U	0.5	U	n/c
"	"	6/24/03	0.3	U	0.3	U	0.5	U	n/c
11MC	Unfiltered water	5/28/03	0.3	U	0.3	U	0.5	U	n/c
"	"	6/24/03	0.3	UJ	0.3	UJ	0.4	UJ	n/c
Brender Creek									
3MC	Unfiltered water	4/9-10/03	**2.3**		**1.0**		**0.3**	J	**3.6**
"	"	5/29/03	**3.6**		**2.1**		**1.3**		**7.0**
"	"	6/24/03	**3.1**		**2.1**		**0.8**	J	**6.0**
3MC	Filtered water	4/9-10/03	**1.6**		**0.8**		**0.2**	J	**2.6**
"	"	6/24/03	**1.8**		**1.2**		**0.5**	J	**3.5**
BRENPZ1	Unfiltered water	5/29/03	**17**		**4.4**		**10**		**31**
"	"	6/24/03	**11**		**3.5**		**5.1**	J	**20**
UPBREN	Unfiltered water	6/25/03	n/a		n/a		n/a		n/a
Peshastin Canal									
PESHAST1	Unfiltered water	6/25/03	**1.8**		**0.4**		**1.0**	J	**3.2**
Yaksum Creek									
7AMC	Unfiltered water	4/10/03	**14**		**5.3**		**6.0**		**25**
"	"	" (rep)	**12**		**4.0**		**5.2**		**21**
"	"	6/24/03	**28**		**10**		**17**	J	**55**
"	"	" (rep)	**27**		**10**		**24**	J	**61**
7AMC	Filtered water	4/10/03	**10**		**3.6**		**4.2**	J	**18**
	"	6/24/03	**9.1**		**4.1**		**5.1**	J	**18**
7MC	Unfiltered water	5/28/03	**62**		**22**		**49**		**133**
"	"	" (rep)	**59**		**22**		**47**		**128**
YAKPZ1	Unfiltered water	5/29/03	**3.5**		**2.6**		**5.1**		**11**
"	"	6/24/03	**3.2**		**2.8**		**2.1**		**8.1**
YAKPZ1	Ground water	5/29/03	0.3	U	0.3	U	0.5	U	n/c
"	"	6/24/03	0.3	U	0.3	U	0.5	U	n/c

Table 4 (Cont) Concentrations of DDT (ng/l) in Surface Water and Shallow Ground Water.

Location	Sample Type	Date	4,4'-DDE		4,4'-DDD		4,4'-DDT		t-DDT
Centrifuge Blank		4/10/03	**0.5**		**0.1**	J	**0.1**	J	**0.7**
Field Blank		5/29/03	0.3	UJ	0.3	UJ	0.5	UJ	n/c
"		6/25/03	n/a		n/a		n/a		n/a
Filter Blank		6/24/03	0.3	U	0.3	U	0.5	UJ	n/c

Notes:
Detected values in **bold**
J = estimated concentration
U = undetected at concentration shown
UJ = undetected at estimated concentration shown
B = concentration shown is less than five times the amount found in an associated laboratory blank
NJ = there is evidence that the analyte is present and the concentration shown is an estimate
n/c = not calculated
n/a = not analyzed
Shaded values exceed criteria

Loading Capacity and Load Allocations

Total DDT targets

Ecology selected targets for t-DDT that will protect beneficial uses in the Mission Creek Watershed. Additionally, targets should be interpreted to apply so that water quality standards are met on a daily basis. As discussed in the introductory sections of this report, there are two sets of relevant criteria - one set to protect aquatic life through chronic exposure (1 ng/l for DDT metabolites or t-DDT) and another set to protect human health (0.59 ng/l for 4,4'-DDE and 4,4'-DDT, and 0.83 ng/l for 4,4'-DDD). Both sets of criteria apply in the Mission Creek Watershed. A reasonable, simple, and slightly conservative approach is to use the t-DDT criterion of 1 ng/l. Based on the average composition of water samples (56 percent 4,4'-DDE, 17 percent 4,4'-DDD, and 27 percent 4,4'-DDT), water with 1 ng/l t-DDT would typically meet the human health criteria. Conversely, selecting the human health criteria as targets could theoretically double the t-DDT concentration before the target was met (0.59 ng/l 4,4'-DDE + 0.83 ng/l 4,4'-DDD + 0.59 ng/l 4,4'-DDT = 2.0 ng/l t-DDT). Both criteria must be met to comply with water quality standards. Meeting the 1 ng/l target for t-DDT should result in meeting the human health criteria for DDT, DDE, and DDD.

The percent reduction of DDT loading necessary to meet the t-DDT criteria are called the target loads. Target loads are based on the loading capacity of the water body. Target loads for t-DDT were calculated for Mission, Brender, and Yaksum creeks (Table 5). Target loads were calculated using the formula:

$$\textit{Target Load (mg/day)} = CC_w \times (10^{-6}\ mg/ng) \times HMQ \times (86{,}400\ s/day)$$

Where:

- CC_w = DDT criterion in unfiltered water (ng/l)
- HMQ = harmonic mean discharge (l/s

Harmonic mean discharge for Mission Creek at Cashmere is 138 liters per second (l/s) based on data from May 1996 through April 2004 (no data for water years 2000 and 2001). Harmonic mean discharge for Brender Creek at Cashmere is 86 l/s based on data from February 1997 through January 2004 (no data for water years 2000 and 2001). Yaksum Creek discharge has a harmonic mean of 18 l/s based on 15 measurements taken by the Chelan County Conservation District (CCCD) (1995-1996) and Ecology (2000, 2003).

Table 5: Load reductions required to meet target t-DDT loads in Mission, Brender, and Yaksum Creeks.

Stream/Location	Harmonic Mean Discharge (l/s)	t-DDT Criterion (ng/l)	Target Load (mg/d)	Average t-DDT (ng/l)	Current Load (mg/d)	Load Reduction (mg/d)	Load Reduction (%)
Mission Creek – 2MC	138	1	12	3.2	38	26	69
Mission Creek – MISSPZ1	97	1	8.4	0.4	3.4	(5.0)	(150)
Brender Creek – 3MC	86	1	7.4	11	84	77	91
Brender Creek – BRENPZ1	37	1	3.2	26	83	80	96
Yaksum Creek – near mouth	18	1	1.6	62	96	94	98

( ) = reserve capacity

The percent reduction load allocation for t-DDT presented in Table 5 is calculated based on the harmonic mean discharge. To meet requirements of the Clean Water Act, it is assumed that the percent reduction for each site in the watershed will apply to the daily time scale and longer so that water quality standards for t-DDT will be met on a daily basis. Table 5 also shows current t-DDT loads for each stream using the formula:

Current Load (mg/day) = AC_w x *(*10^{-6} *mg/ng)* x *HMQ* x *(86,400 s/day)*

Where:

- AC_w = average concentration of DDT in unfiltered water (ng/l) based on pooled 2000 and 2003 data
- HMQ = harmonic mean (reciprocal of the arithmetic mean of the sum of the reciprocals of a specified set of numbers) discharge (l/s)

Current loads are considered representative of average flow conditions since they were collected under flow regimes ± 25 percent of average.

The greatest t-DDT load reductions are required in Yaksum Creek (98 percent reduction) and Brender Creek where >90 percent reductions are required to meet target loads. Mission Creek at MISSPZ1 (see Figure 3) has a reserve capacity (i.e., amount below assimilative capacity) of 5 mg/day, whereas 2MC requires a 69 percent (26 mg/day) load reduction to meet its target load. Meeting the target load at 2MC should be achievable if the current t-DDT load in Yaksum Creek is reduced by approximately 30 percent. This should be possible even if the load at MISSPZ1 approaches its assimilative capacity.

In Brender Creek, current t-DDT loads at the upstream location (BRENPZ1) and at the mouth (3MC) are nearly equal as are the load reductions required to meet targets. The result of meeting the target load at BRENPZ1 could theoretically yield 3 mg/day reserve capacity at 3MC.

Margin of safety

This TMDL evaluation incorporates the following assumptions which provide a margin of safety.

- The target numerical water quality criterion (1 ng/l) is conservative because at this concentration human health criteria will be met based on the typical composition of water samples (56 percent 4,4'-DDE, 17percent 4,4'-DDD, and 27 percent 4,4'-DDT). In the present study, all water samples with t-DDT < 1 ng/l met the individual criteria for 4,4'-DDE, 4,4'-DDD, and 4,4'-DDT. Conversely, selecting the human health criteria as targets could theoretically double the t-DDT concentration before the target was met (0.59 ng/l 4,4'-DDE + 0.83 ng/l 4,4'-DDD + 0.59 ng/l 4,4'-DDT = 2.0 ng/l t-DDT). The target numerical water quality criterion was used to calculate target loads.

- The use of harmonic mean discharges to calculate target loads increases the margin of safety since harmonic means are lower than arithmetic means, especially in cases where discharge data have a wide spread. For instance, the harmonic mean discharge in

Mission Creek (2MC) is 138 l/s whereas the arithmetic mean is 658 l/s. Target t-DDT loads calculated using the harmonic and arithmetic mean flows are 12 mg/d and 56 mg/d, respectively, with the former, more conservative target used in this assessment.

Summary Implementation Strategy

Implementation overview

The goals of this implementation plan are to:

(1) Provide guidance for reducing and/or preventing the impacts of pollution sources to water bodies within the Mission Creek Watershed

(2) Provide a strategy to meet water quality standards.

Several milestones in the development of the TMDL are worth noting. Field studies addressing the 303(d) listed parameters were developed and conducted by Ecology from 2002-2004, with assistance from the CCCD. Technical analyses of the studies were completed from 2004-2006. Numerous drafts of the technical reports were reviewed and commented on by the WQTS and WWPU. Ecology responded to the comments and incorporated them into the technical reports. Scientists conducting the work provided numerous presentations and engaged in discussions with the group.

The WQTS and WWPU assisted Ecology with development of this submittal document from 2005-2007. The process included education, outreach, and assistance with media coverage.

Implementation plan development

This summary implementation strategy (SIS) was developed with input from several members of the WQTS. Implementation of many action items published in the final Wenatchee Watershed Management Plan (WWMP) should help lower t-DDT loading to Mission Creek, its tributaries and the Wenatchee River. Activities fall into one of three categories: implementation of an existing law or rule; implementation of educational and voluntary measures to protect water quality; and monitoring and reporting activities related to water quality improvements.

Implementation activities

The following actions were developed by the WQTS and are based on recommendations from the TMDL technical study, *DDT Contamination and Transport in the Lower Mission Creek Basin, Chelan County, Total Maximum Daily Load Assessment* (Serdar and Era-Miller, 2004). These activities are published in the WWMP. Adaptive management may identify other activities that would contribute to meeting the targets identified in this TMDL.

If implemented, the nonpoint source control activities listed here should address the 303(d) listings for DDT, DDD, and DDE in this TMDL for Mission Creek, Brender Creek, and Yaksum Creek by 2018.

> *Implementation Action Item #1.* Significant reductions in DDT loads may be achieved by preventing bank erosion or by other means of limiting transport of upland soils to streams. Best Management Practices (BMPs), such as riparian buffers and wetlands, can also filter and uptake DDT from surface and groundwater (Burgoon, 2002). Many BMPs are currently being implemented in the watershed. BMPs should be continued, refined,

and expanded to further reduce erosion, surface runoff, TSS in the water column, and groundwater transport of DDT. BMPs include farm practices, storm water runoff, riparian vegetation planting, orchard conversions, residential practices, riparian buffers, wetlands, etc. These and other appropriate BMP actions BMP and locations should be coordinated by members of the Planning Unit and its committees.

Implementation Action Item #7. Activities should be identified and undertaken to provide ongoing outreach, education, and technical assistance to growers, streamside landowners, developers, and the general public.

Implementation Action Item #9. Development over old orchards is a potential concern. Measures should be implemented to prevent DDT-laden orchard soils, disturbed during construction, from being transmitted to streams and lakes in the watershed. Language requiring measures to prevent DDT-laden soils from entering the waterways during and after construction should be developed by and included in county and municipality development ordinances, growth management plans, and critical area ordinances. The *Stormwater Management Manual for Eastern Washington* or an equivalent document should be utilized in developing ordinances, and guiding municipal, private, and construction stormwater practices.

Specific BMPs should be coordinated between individual land owners/land managers and agency staff with proper qualifications to plan BMPs. For example, the CCCD, U.S. Department of Agriculture (USDA) and Natural Resource Conservation Service (NRCS) employ staff members that are trained to design conservation plans for farms.

In addition to these implementation actions from the Wenatchee River Watershed Management Plan (WRWMP), the Washington State Department of Agriculture (WSDA) Waste Pesticide Program provides a means to reduce the potential for release of DDT contamination to the environment. Annually, the Waste Pesticide Program provides the opportunity for farmers in the Wenatchee River Watershed to turn in old and unusable pesticides to the WSDA for proper disposal. The collection of concentrate product greatly reduces the potential for additional DDT release to the environment and loading to streams in the Mission Creek Watershed.

Implementation activities table

The table below contains general suggestions for voluntary and required actions to be made by each of the entities involved with the implementation of the Mission Creek Watershed DDT TMDL. Implementation actions will be described in more detail in the WQIP. Some actions are dependent upon funding and cooperative agreements. Some actions are voluntary and others are regulatory. Actions may be subject to change based on the feedback and responses from potential contributors, ongoing adaptive management, and regulatory requirements.

Table 6: Organization of TMDL entities and their contributions. (A list of acronyms is provided at the end of the table).

Implementation Action Item	Potential Cooperators	YEAR 2008	2008-16	2012	2013	2017	2018	2020	2021
Complete WQIP		X							
BMPs to reduce DDT transport to surface waters (#1)	WQTS, WWPU, CCCD, Ecology, Agriculture, CC, developers, municipalities, other stakeholders		X						
Monitor BMPs and DDT targets (#2)	WQTS, WWPU, CCCD, Ecology, Agriculture, CC, developers, municipalities, other stakeholders		X						X
Monitor during rain events, spring thaw, and irrigation (#3)	WQTS, WWPU, CCCD, Ecology, other stakeholders		X						
Ground water monitoring (#4)	WQTS, WWPU, CCCD, Ecology, other stakeholders		X						
Icicle-Peshastin Irrigation canal DDT monitoring, BMPs (#5)	WQTS, WWPU, CCCD, Ecology, IPID, other stakeholders		X						
Irrigation sediment transport, BMPs (#6)	WQTS, WWPU, CCCD, Ecology, irrigation districts, other stakeholders		X						
Education outreach and technical assistance (#7)	WQTS, WWPU, CCCD, Ecology, Agriculture, CC, developers, watershed groups, municipalities, other stakeholders		X						
Provide funding and identify monitoring entities (#8)	Ecology, WWPU, agencies, other funding entities		X						
Development ordinances (#9)	CC, municipalities		X						
Waste Pesticide Program	WSDA	X	X	X	X	X	X	X	X
Collect data at points of compliance	Ecology, other stakeholders					X		X	
Review data and targets	Ecology				X		X	X	
Implement adaptive management changes	Ecology		X	X	X	X	X	X	
Water Quality standards met	Ecology and EPA determine								X

The following abbreviations are used in Table 6:

BMP	Best management practices
CC	Chelan County
CCCD	Chelan County Conservation District
CDHD	Chelan-Douglas Health District
DDT	dichloro-diphenyl-trichloroethane
DNR	Department of Natural Resources
Ecology	Washington State Department of Ecology
EPA	Environmental Protection Agency
IPID	Icicle-Peshastin Irrigation District
WWPU	Wenatchee Watershed Planning Unit
TMDL	Total Maximum Daily Load
WQTS	Water Quality Technical Subcommittee
WSDA	Washington State Department of Agriculture

Reasonable assurances

This TMDL addresses only nonpoint sources of pollution, so formal reasonable assurance is not required. This TMDL was developed with intense collaboration by the Wenatchee Watershed Planning Unit WQTS. Many action items published in the Wenatchee Watershed Management Plan, if implemented, will help control t-DDT transport to surface waters in the Mission Creek Watershed. Monitoring and adaptive management of implementation actions will help direct appropriate actions to reduce t-DDT loading to surface waters of the Mission Creek Watershed.

Adaptive management

The Mission Creek Watershed DDT TMDL is the result of a partnership between Ecology and the WWPU and WQTS. Ecology published this TMDL after the WQTS reviewed and commented on the technical report, titled *DDT Contamination and Transport in the Lower Mission Creek Watershed, Chelan County Total Maximum Daily Load Assessment*. Additionally, the WQTS helped develop and review the SIS for this TMDL.

Information presented in this TMDL represents the current state of knowledge regarding DDT in the Mission Creek Watershed. It is the understanding of the WQTS that additional studies may be performed to fill data gaps and to determine the effectiveness of implementing actions identified in this SIS or the WQIP.

A WQIP will be developed for this TMDL that will include a monitoring plan to evaluate implementation measures. If planned implementation activities do not produce the expected or required results, Ecology, members of the WQTS, or other entities may choose to perform more studies to identify significant sources of t-DDT to the creeks in the study area. The direction of the TMDL may be modified as a result of future monitoring results.

Monitoring strategy

Monitoring is an important part of this implementation strategy. Monitoring related to this TMDL should track implementation actions and track water quality improvements that result from implementation actions. In addition, monitoring conducted related to this TMDL should comply with the Water Quality Data Act (WQDA) codified in RCW 90.48.570 through

90.48.590 and Ecology's Water Quality Program Policy 1-11. Ecology is responsible for effectiveness monitoring programs that determine if TMDL targets are being met. There are many types of monitoring that local government and organizations could effectively conduct.

Listed below are action items from the WWMP describing monitoring needs related to this TMDL. These action items are presented as they are written in the WWMP.

> *Implementation Action Item #6.* Assessments are recommended for all irrigation systems in the watershed to identify any mechanisms that may contribute to sediment transport which are not yet being addressed by BMPs. Actions should be identified and implemented to address the findings.
>
> *Implementation Action Item #4.* More comprehensive groundwater monitoring should be conducted, including further assessment of the relationship between surface water, groundwater, and the fate and transport of DDT compounds.
>
> *Implementation Action Item #2.* A phased monitoring approach should be conducted to assess the effectiveness of BMPs and DDT-TSS reduction efforts. This may take time to achieve as TSS loads are reduced and DDT levels are monitored.
> *Implementation Action Item #3*. Evaluation of soil transport to streams should be conducted during large rainfall events when visual observations can be made and/or sections of streams with high sediment runoff and TSS can be isolated. An assessment should be conducted to investigate if any other events contribute soil to streams such as spring thaw processes or irrigation practices.
>
> *Implementation Action Item #10.* Assessments are recommended for stormwater control systems in the watershed to identify any mechanisms that may contribute to sediment transport which are not yet being addressed by BMPs. Actions should be identified and implemented to address the findings through a list of prioritized projects.
>
> *Implementation Action Item #5.* An assessment should be conducted to investigate if the Icicle and Peshastin canals are transporting DDT. It is not certain how canals may transport DDT since no wastewater enters the systems and most canals are lined. Current irrigation system BMPs should continue that maintain lined canals and limit rapid increased flows during non-emergency situations. Lining of any remaining unlined canals should be encouraged. Other BMPs include actions such as irrigation water management, irrigation return drain monitoring and efficiencies, irrigation spill points where erosion control can be reduced, spoil pile placement, and maintaining canyon crossings.

Ecology will complete an effectiveness monitoring plan and present it in the WQIP, which is due one year after EPA's approval of this TMDL.

Potential Funding Sources

The Wenatchee Watershed Management Plan identified Ecology's grants program as a potential funding source for implementation activities. A variety of funding sources could be pursued by various members of the WQTS or other stakeholders. Listed below is an action item from the WWMP that describes the WWPU's plans for seeking funding sources. A more thorough presentation of funding sources will be presented in the WQIP.

> *Implementation Action Item #8.* The Department of Ecology may provide funding assistance through its grants and loans programs to implement actions and ongoing monitoring. Other funding sources should be identified and applications submitted to provide funding for ongoing activities.

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Appendix A

This TMDL's technical report *DDT Contamination and Transport in the Lower Mission Creek Basin, Chelan County* can be viewed at the following web site:

http://www.ecy.wa.gov/biblio/0403043.html

Appendix B

Responsiveness Summary to Comments Received During Public Comment Period.

Ecology held a public comment period for this report from May 23, 2007 to June 22, 2007. The public comment period was advertised in the following Chelan County newspapers:

- The Leavenworth Echo
- The Cashmere Valley Record
- The Wenatchee World

Ecology received the following comment during the public comment period:

Re: the most impassioned plea I made many months age regarding clarity and understandability in the DDT report.

Could you state at least once in the report what an ng/l or an ng/g means?

It might be interesting to the public, and informative if we said "parts per trillion" or something that the mind can grasp as being very, very small. An ng/L means nothing.

The public is not being informed, just alarmed, by ng/l.

Ecology's response to the comment:

Response: Ecology incorporated your suggestion to the report. The first time we use nanograms per liter (ng/L) in the report and the report's executive summary, we also state that 1 ng/L is equal to one part per trillion. In addition we added that a nanogram per gram is equal to one part per billion in the portion of the report that ng/g is used.