

**Zip files for Publication No. 11-03-055-Addendum-1, Control of Toxic Chemicals in Puget Sound: Assessment of Selected Toxic Chemicals in the Puget Sound Basin, 2007-2011 – Addendum No. 1: Evaluation of Fate and Transport Mechanisms for Primary Releases of Copper, PCBs, and PBDEs**

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Table A1. Primary constrained source of chemical of concern grouped by initial modes of release

[List of sources are taken from Roberts et al., 2011. **Abbreviations:** PVC, polyvinyl chloride]

**Household products to sanitary**

Aquatic-use algaecides in pools, fountains, spas  
Body lotion  
Dental amalgam extraction  
Deodorant (solid)  
Hair spray (aerosol and pump spray)  
PVC coated fabric  
Washing machine rinse water

**Water Conveyance**

Plumbing fixtures, pipes, and solder  
PVC hoses and profiles (indoor)

**Air (includes volatilization of household products and fugitive emissions)**

Fragrance  
Hair spray (aerosol and pump spray)  
Indoor commercial Office space  
Indoor residential space  
Lacquers and paint  
Nail polish  
Printing inks  
PVC cables (indoor)  
PVC coated fabric  
PVC films, sheets, coated products  
PVC flooring  
PVC hoses and profiles (indoor)  
PVC wall coverings

**Industrial- to sanitary**

Army base

**Industrial Air Emissions**

Boat manufacturer  
Cement plants  
Crematoria emissions  
Medical waste incineration  
Paint and coating manufacturer  
Plastics manufacturer  
Pulp and paper mills  
Specialty glass manufacturer  
Wood treatment facility

**Residential Combustion**

Residential fuel use, except wood  
Woodstoves and fireplaces

**Product Use to Landfill**

Auto convenience switch disposal  
Button cell batteries  
Fluorescent lamp disposal  
Indoor commercial office space  
Indoor residential space  
Paint and coating manufacturer  
PVC cables (indoor)  
PVC coated fabric  
PVC films, sheets, coated products  
PVC flooring  
Shoe soles  
Thermometers  
Thermostat disposal

Table A2. Primary unconstrained source of chemical of concern grouped by initial modes of release.

[List of sources are taken from Roberts et al., 2011. **Abbreviations:** CCA, copper, chromate, arsenic; PVC, polyvinyl chloride]

### **Buildings & Grounds**

CCA-treated wood  
PVC cables (outdoor)  
PVC coil coated roofing  
PVC hoses and profiles (outdoor)  
PVC roofing material  
Roofing materials  
Sealants (caulking), adhesives

### **Mobile Sources**

Agricultural equipment emissions  
Airport service equipment emissions  
Asphalt erosion and leaching  
Aviation fuel combustion  
Brake pad wear  
Car undercoating  
Cigarette smoke  
Coal tar sealants  
Commercial equipment emissions  
Construction equipment emissions  
Distillate fuel oil emissions  
Heavy duty diesel vehicle emissions  
Heavy duty gasoline vehicle emissions  
Industrial equipment emissions  
Lawn and garden equipment emissions  
Light duty diesel vehicle emissions  
Light duty gasoline vehicle emissions  
Locomotive emissions  
Logging equipment emissions  
Motor oil drips and leaks  
Oil field equipment emissions  
Railroad maintenance equipment emissions  
Recreational boat emissions  
Recreational equipment emissions  
Tire wear  
Wheel weight loss

### **Land Applications as liquids**

Pesticide use on residential grounds  
Improper disposal of used oil following oil changes  
Minor gasoline spills from fueling vehicles and non-road equipment  
Oils in transforms and capacitors  
Pesticide use on commercial and industrial grounds  
Pesticide use on crops  
Pesticide use on golf course use  
Petroleum spills (major and minor), leaks  
Right-of-way maintenance - railroads  
Right-of-way maintenance - state highways

### **Land Applications as solids**

Creosote treated railroad ties  
Creosote treated utility poles  
Fertilizers  
Fertilizers and micronutrients  
Micronutrients  
Shoe soles  
Urban lawn & garden use of pesticides

### **Combustion from stationary sources and Fugitive emissions**

Backyard burn barrels  
Residential trash burning  
Residential yard waste burning  
Aluminum mills  
Fragrance  
Gas station emissions  
Hair spray (aerosol and pump spray)  
Metal foundries  
Nail polish  
Naval shipyard  
Petroleum refineries  
Pulp and paper mills  
PVC films, sheets, coated products  
Specialty glass manufacturer

### **Water Applications**

Ammunition, Hunting Shot Use  
Antifouling Paint  
Aquatic Weed Control  
Creosote Treated Marine Pilings  
Fishing Sinker Loss

Table A3. Percentage of total copper in the dissolved phase of runoff measured in urban areas.

[Abbreviations: mg/L; milligram per liter; µg/L, microgram per liter; —, no data reported]

Location	Type of runoff	Total Suspended Solids mg/L	Method of Calculation	Copper		Percentage in dissolved phase	Reference
				Dissolved µg/L	Total		
Marquette, MI	Residential Roof	81	Storm weighted	10	6.6	66	Steuer et al., 1997
	Commercial Roof	115	Storm weighted	23	17.8	77	Steuer et al., 1997
Nantes, France	Bridge Runoff	16 - 267	Ratio of medians	7.3 - 139	11 - 146	55	Legret and Pagotto, 1999
Seattle, WA	Bridge Runoff	6 - 49.1	Median of ratios (event means)	38 - 65	16.3 - 54.3	52	King County (2005)
Madison, WI	Residential Driveways	306	Ratio of medians	9	17	53	Bannerman et al., 1993
Madison, WI	Residential Feeder Street	662	Ratio of medians	9	23	39	Bannerman et al., 1993
Madison, WI	Residential Collector	326	Ratio of medians	24	56	43	Bannerman et al., 1993
Madison, WI	Commercial Parking Lots	15	Ratio of medians	6	15	40	Bannerman et al., 1993
Madison, WI	Commercial Arterials	232	Ratio of medians	18	46	39	Bannerman et al., 1993
Madison, WI	Industrial Parking Lots	312	Ratio of medians	15	41	37	Bannerman et al., 1993
Madison, WI	Industrial Collector Street	763	Ratio of medians	18	76	24	Bannerman et al., 1993
Madison, WI	Industrial Arterials	690	Ratio of medians	14	74	19	Bannerman et al., 1993
Paris, France	Street runoff	—	Medians of ratios	—	—	57 -100	Garnaud et al. 1999
Five Eastern U.S. Cities	Urban runoff	—	Ratio of medians	23	218	11	Sansalone et al., 1998
Owens-Mills, MD	Stormwater	29.- 278	Medians of ratios	—	39	21 - 68	Camponelli et al., 2010

Table A4. Summary of percent removal efficiencies of total copper within biofilters.

[Data from International Storm Water BMP Database, 2010. Percent removal efficiency =  $100 * [1 - (\text{Outlet concentration}/\text{Input concentration})]$ . A negative value indicates that the outlet concentration is greater than inlet concentration. **Abbreviations:** BMP, Best Management Practices; RVTS, roadside vegetated treatment sites; m, meter; WPCL, water pollution control laboratory]

Site name (name used in Master BMP database)	Location	Number of paired sets	Percent removal efficiency		
			Median	Minimum	Maximum
Grass strip					
Carlsbad strip (Carlsbad Biofiltration Strip)	Carlsbad, CA	10	87	74	94
Yorba Linda D RVTS (Yorba Linda 5 RVTS) (13.0 m)	Orange, CA	18	53	-330	84
Irvine A RVTS (Sand Canyon RVTS)	Orange, CA	6	53	-17	70
Sacramento D RVTS (Sacramento 5 RVTS) (8.4 m)	Sacramento, CA	15	53	-23	83
San Onofre B RVTS (Camp Pendleton 3 RVTS) (5.3 m)	San Onofre, CA	13	48	-12	77
San Onofre A RVTS (Camp Pendleton 2 RVTS) (1.3 m)	San Onofre, CA	22	51	-2	84
San Onofre C RVTS (Camp Pendleton 4 RVTS) (9.9 m)	San Onofre, CA	10	67	0	88
San Rafael RVTS	San Rafael, CA	34	82	-4	97
Redding A RVTS (299 2 RVTS)	Shasta, CA	29	5	-115	74
Redding C RVTS (299 4 RVTS)	Shasta, CA	22	27	-107	69
Redding B RVTS (299 3 RVTS)	Shasta, CA	25	30	-2713	78
Cottonwood RVTS (9.3m)	Shasta, CA	15	72	56	95
Overall median			53		
Grass swale					
Palomar Swale (I-5 North of Palomar Airport Road)	Carlsbad, CA	9	50	-129	58
Russell Pond Bioswale	Portland, OR	6	7	-29	25
WPCL bioswale east	Portland, OR	10	37	15	82
West Swale (WPCL Bioswale West)	Portland, OR	10	38	-1	80
SR-78 / Melrose Dr	Vista, CA	5	62	48	86
Shop Creek	Aurora, CO	14	0	-100	50
Overall Median			38		

Table A5. Summary of percent removal efficiencies of dissolved copper within biofilters.

[Data from International Storm Water BMP Database, 2010. Percent removal efficiency =  $100 * [1 - (\text{Outlet concentration}/\text{Input concentration})]$ .. A negative value indicates that the outlet concentration is greater than inlet concentration. **Abbreviations:** BMP, Best Management Practices; RVTS, roadside vegetated treatment sites; m, meter; WPCL, water pollution control laboratory]

Site name (name used in Master BMP database)	Location	Number of paired sets	Percent removal efficiency		
			Median	Minimum	Maximum
Grass strip					
Carlsbad strip (Carlsbad Biofiltration Strip)	Carlsbad, CA	10	84	67	91
Yorba Linda D RVTS (Yorba Linda 5 RVTS) (13.0m)	Orange, CA	18	30	-155	74
Irving A RVTS (Sand Canyon 2 RVTS)	Orange, CA	6	54	33	78
Sacramento D RVTS (Sacramento 5 RVTS) (8.4m)	Sacramento, CA	11	-31	-253	66
San Onofre A RVTS (Camp Pendleton 2 RVTS) (1.3m)	San Onofre, CA	22	14	-79	47
San Onofre B RVTS (Camp Pendleton 3 RVTS) (5.3m)	San Onofre, CA	14	17	-12	49
San Onofre C RVTS (Camp Pendleton 4 RVTS) (9.9m)	San Onofre, CA	10	36	-7	80
San Rafael RVTS	San Rafael, CA	34	73	-20	98
Redding C RVTS (299 4 RVTS)	Shasta, CA	19	-32	-180	40
Redding B RVTS	Shasta, CA	21	-17	-178	40
Redding A RVTS (299 2 RVTS)	Shasta, CA	22	-16	-133	50
Cottonwood RVTS (9.3m)	Shasta, CA	16	44	-15	94
Overall median			24		
Grass swale					
Russell Pond Bioswale	Portland, OR	6	-3	-56	15
WPCL bioswale east	Portland, OR	10	4	-49	55
West Swale (WPCL Bioswale West)	Portland, OR	10	5	-45	55
Palomar Swale (I-5 North of Palomar Airport Road)	Carlsbad, CA	9	13	-35	42
SR-78 / Melrose Dr	Vista, CA	5	58	33	63
Overall Median			5		

Table A6. Summary of percent removal efficiencies of total copper within detention ponds of various construction.

[Data from International Storm Water BMP Database, 2010. Percent removal efficiency =  $100 * [1 - (\text{Outlet concentration}/\text{Input concentration})]$ . A negative value indicates that the outlet concentration is greater than inlet concentration. **Abbreviations:** BMP, Best Management Practices; MCTT, multi chambered treatment trains; UAB, University of Alabama; PRF, pollution reduction facility; EDB, extended detention basins; WB, wet basin; RP, retention pond; EMC, even mean concentration]

Site name (name used in Master BMP database)	Location	BMP type	Number of paired sets	Percent removal efficiency			Comments
				Median	Minimum	Maximum	
Detention pond (dry)							
MCTT Main settling chamber (MCTT, Pilot Scale UAB,	Birmingham, AL	Detention -	11	15	-159	93	
Whitaker PRF (Whitaker Ponds PRF)	Portland, OR	Underground Vault, Tank or Pipe(s)	3	-4	-11	-4	
5_605 EDB (I-5 / I-605 EDB)	Downey, CA	Detention Basin (Dry) - Concrete or Lined Tank/Basin With Open Surface	13	5	-17	80	
Greenville Pond	Greenville, CA		8	37	20	56	
Manchester (I-5/Manchester (east))	Encinitas, CA	Detention Basin (Dry) - Surface Grass- Lined Basin That	13	61	22	82	
Lex Hills Pond (Lexington Hills - Detention Pond)	Portland, OR	Empties Out After A Storm	13	7	-41	35	
Total			61				
Median				11			
Minimum				-4			
Maximum				61			
Retention pond (wet) - surface pond with a permanent pool							
Lake Munson	Tallahassee, FL		3	72			From database text, could not be confirmed from raw data
<a href="#">La Costa WB</a>	Encinitas, CA		17	53	-39	86	
Heritage Retention Pond	Richmond Hill, ON		21	55	11	95	
<a href="#">Tampa Office Pond 1993-95</a>			57	33	-400	89	
Lake Ellyn	Glen Ellyn, IL		7	0	77	88	From database text Many values qualified
<a href="#">Shop Creek Pond (95-97)</a>	Aurora, CO		15	50	0	88	
South Central Stormwater Facility	Tallahassee,TX		4	33	-172	56	
<a href="#">Phantom Pond A</a>	Bellevue, WA		14	19	-17	97	
Total			138				
Median				42			
Minimum				0			
Maximum				72			
Vaults (wet) - underground vault or pipe							
Lakewood RP (95)	Lakewood, CO		3	30	0	59	
Lakewood RP (95)	Lakewood, CO		7	73	-20	88	
Lakewood RP (97-98)	Lakewood, CO		11	24	-210	95	
Total			21				
Median			Median	30			
Minimum			Minimum	24			
Maximum			Maximum	73			

Table A7. Summary of percent removal efficiencies of dissolved copper within detention ponds of various construction.

[Data from International Storm Water BMP Database, 2010. Percent removal efficiency =  $100 * [1 - (\text{Outlet concentration}/\text{Input concentration})]$ .. A negative value indicates that the outlet concentration is greater than inlet concentration. **Abbreviations:** BMP, Best Management Practices; EDB, extended detention basins; PRF, pollution reduction facility; MCTT, multi chambered treatment trains; WB, wet basin; RP, retention pond]

Site name (name used in Master BMP database)	Location	BMP type	Number of paired sets	Percent removal efficiencies			Comments
				Median	Minimum	Maximum	
Detention pond (dry)							
Manchester (I-5/Manchester (east))	Encinitas, CA	Detention Basin (Dry) - Surface Grass-Lined Basin That Empties Out After A Storm	13	0	-52	46	
5_605 EDB (I-5 / I-605 EDB)	Downey, CA	Detention Basin (Dry) - Surface Grass-Lined Basin That Empties Out After A Storm	13	-4	-30	72	
Lex Hills Pond (Lexington Hills - Detention Pond)	Portland, OR	Detention - Underground	13	-9	-151	24	
Whitaker PRF (Whitaker Ponds PRF)	Portland, OR	Vault, Tank or Pipe(s)	3	7	0	43	
MCTT Main settling chamber	Birmingham, AL		12	17	-558	93	
Total			54				
Median				0			
Minimum				-9			
Maximum				17			
Retention pond (wet)							
<a href="#">La Costa WB</a>	Encinitas, CA	Surface Pond With a Permanent Pool	17	16	-106	51	
<a href="#">Shop Creek Pond (90-94)</a>	Aurora, CO		13	20	-200	71	
Lake Ellyn	Glen Ellyn, IL		18		13	54	From database text
Total			48				
Median				18			
Minimum				16			
Maximum				20			
Vaults (wet)							
Lakewood RP (95)	Lakewood, CO	Underground vault or pipe	3	22	-125	38	
Lakewood RP (95)	Lakewood, CO		7	-29	-80	94	
Lakewood RP (97-98)	Lakewood, CO		16	42	-38	93	
Total			26				
Median				22			
Minimum				-29			
Maximum				42			



Table A8. Summary of precipitation data in Mill Creek basin used to calculate roof and road loads.

[Abbreviations: cm/hr, centimeters per hour; cm, centimeters; cm/day, centimeters per day; SEATAC, Seattle-Tacoma International Airport; Jr HS, junior high school]

		Storm Event					Previous storm greater than 0.13 cm/day				
		Most Intense Rainfall (cm/hr)					Most Intense Rainfall (cm/hr)				
Duration of			Precipitation-Event total (cm)					Antecedent Period (days)			
Date of Sampling	Storm (days)										
			SEATAC	Panther Creek	Sequoia Jr HS	Average		SEATAC	Panther Creek	Sequoia Jr HS	Average
8/29/2005	2	0.33	0.61	0.64	0.94	0.73	0.01	11	11	11	11
9/29/2005	2	0.13	0.69	1.52	1.04	1.08	0.03	13	19	13	15
12/19/2005	2	0.23	1.5	0.97	0.74	1.07	0.03	17	17	17	17

Table A9. Average daily traffic, average weekday traffic, length of road segments and the vehicle miles traveled for Kent, Washington, in the Mill Creek basin.

[**Abbreviations:** Hwy, highway; S, South; St., street; Pl, Place, R., River; N, North; W, West; SE, Southeast; Rd, Road; Dr, Drive; SR, State Route; NB, northbound; --, not applicable]

Road	Intersection in which road segment begins	Intersection in which road segment ends	Length of road segment (miles)	Average daily traffic (2005) (vehicles per day)	Average daily vehicle miles traveled (2005) (miles)	Average weekday traffic (2006) (vehicles per day)	Average weekday vehicle miles traveled (2006) (miles)
SR-167	SR 516 NB off ramp	N Central Ave NB off ramp	1.249	109,000	136,096	--	--
SR-167	N Central Ave NB off ramp	N Central Ave NB on ramp	0.182	95,000	17,283	--	--
West Valley Hwy	SW 43rd St	S 190th St	0.643	--	--	29,700	19,086
West Valley Hwy	S 190th St	S 196th St	0.400	--	--	32,300	12,915
West Valley Hwy	S 196th St	S 199th Pl	0.220	--	--	30,800	6,772
S 199th Pl	West Valley Hwy	62 Ave S	0.363	--	--	12,200	4,426
Russell Rd S	62 Ave S	58 Pl S	0.424	--	--	13,400	5,685
Russell Rd S	58 Pl S	Green R	0.062	--	--	6,700	413
S 196th St	West Valley Hwy	80th Ave S	0.745	--	--	13,300	9,905
80th Ave S	S 182nd St	S 190th St	0.549	--	--	4,900	2,692
80th Ave S	S 194th St	S 196th St	0.131	--	--	4,900	640
S 196th St	80th Ave S	81st Ave S	0.116	--	--	14,000	1,622
West Valley Hwy	S 199th Pl	S 212th St	0.778	--	--	27,900	21,702
S 212th St	West Valley Hwy	64th Ave S	0.247	--	--	20,200	4,998
S 212th St	64th Ave S	59 Pl S	0.294	--	--	27,400	8,066
S 212th St	59 Pl S	Green R	0.139	--	--	25,300	3,512
S 212th St	West Valley Hwy	72 Ave S	0.251	--	--	28,900	7,268
S 212th St	72 Ave S	76 Ave S	0.253	--	--	24,200	6,128
S 212th St	76 Ave S	East Valley Hwy	0.503	--	--	25,300	12,727
S 212th St	East Valley Hwy	86 Ave S	0.048	--	--	26,800	1,289
East Valley Hwy	S 212th St	S 210th St	0.074	--	--	25,800	1,915
East Valley Hwy	S 212th St	S 224th St	0.763	--	--	21,100	16,094
West Valley Hwy	S 212th St	S 219th St	0.366	--	--	31,700	11,614
64th Ave S	S 212th St	S 219th St	0.346	--	--	15,000	5,188
76 Ave S	S 212th St	S 228th St	0.989	--	--	5,200	5,142
S 228th St	76 Ave S	West Valley Hwy	0.499	--	--	13,300	6,633
S 228th St	76 Ave S	East Valley Hwy	0.692	--	--	9,500	6,573
East Valley Hwy	S 224th St	S 228th St	0.273	--	--	28,800	7,871
West Valley Hwy	S 228th St	S 226th Pl	0.155	--	--	31,700	4,927
West Valley Hwy	S 228th St	James St	0.773	--	--	28,900	22,342
4th Ave N	S 228th St	James St	0.776	--	--	9,100	7,063
East Valley Hwy	S 228th St	James St	0.742	--	--	31,300	23,212
James St	4th Ave N	67 Pl S	0.079	--	--	11,100	874
James St	West Valley Hwy	4th Ave N	0.463	--	--	17,200	7,961
James St	4th Ave N	East Valley Hwy	0.289	--	--	17,900	5,167
S 240 St	East Valley Hwy	94th Ave S	0.733	--	--	28,700	21,034
West Valley Hwy	James St	W Meeker St	0.323	--	--	21,900	7,070
W Smith St	Lincoln Ave N	4th Ave N	0.415	--	--	10,700	4,437
4th Ave N	W Smith St	James St	0.236	--	--	14,300	3,370
W Meeker St	Lincoln Ave N	4th Ave N	0.306	--	--	5,400	1,651
4th Ave N	W Meeker St	W Smith St	0.102	--	--	11,300	1,158

Road	Intersection in which road segment begins	Intersection in which road segmen ends	Length of road segment (miles)	Average daily traffic (2005) (vehicles per day)	Average daily vehicle miles traveled (2005) (miles)	Average weekday traffic (2006) (vehicles per day)	Average weekday vehicle miles traveled (2006) (miles)
W Smith St	4th Ave N	East Valley Hwy	0.293	--	--	14,800	4,333
East Valley Hwy	James St	W Smith St	0.227	--	--	24,100	5,474
East Valley Hwy	W Smith St	W Meeker St	0.115	--	--	16,500	1,894
W Meeker St	4th Ave N	East Valley Hwy	0.297	--	--	4,900	1,453
W Gowe St	4th Ave N	East Valley Hwy	0.298	--	--	5,800	1,728
East Valley Hwy	W Meeker St	W Gowe St	0.040	--	--	16,500	654
4th Ave N	W Meeker St	Willis St	0.212	--	--	10,800	2,287
East Valley Hwy	W Gowe St	Morton St	0.294	--	--	24,200	7,120
S 240 St	94th Ave S	96th Ave S	0.122	--	--	28,300	3,443
Canyon Dr	East Valley Hwy	94th Ave S	0.857	--	--	32,200	27,607
SE 248 St	Canyon Dr	SR 515	0.677	--	--	5,500	3,723
SR 515	247 Pl	SE 248 St	0.059	--	--	25,600	1,504
S 240 St	96th Ave S	100th Ave S	0.235	--	--	28,300	6,653
SR 515	S 240 St	SE 256th St	0.499	--	--	25,600	12,766
Canyon Dr	94th Ave S	101 Ave SE	0.613	--	--	34,300	21,025
Canyon Dr	101 Ave SE	SR 515	0.179	--	--	32,200	5,765
SR 515	SE 256th St	SE 260 St	0.249	--	--	1,400	348
SE 256th St	SR 515	Kent Kangly Rd	0.053	--	--	32,700	1,742
Kent Kangly Rd	SE 256th St	114 Ave SE	0.642	--	--	26,000	16,703
SE 248 St	SR 515	114 Ave SE	0.713	--	--	5,800	4,136
SE 256th St	SR 515	116 Ave SE	0.527	--	--	11,500	6,065
108th Ave SE	SE 260 St	SE 274 Wy	0.894	--	--	8,500	7,603
108th Ave SE	SE 274 Wy	275 St	0.091	--	--	7,400	674
SE 277 St	104th Ave SE	108th Ave SE	0.217	--	--	21,200	4,609
SE 274 Wy	108th Ave SE	111 Pl	0.183	--	--	12,700	2,330
SE 274 Wy	114 Ave SE	116 Ave SE	0.141	--	--	12,700	1,793

Watershed sum = Vehicle miles traveled

153,380

454,574

Table A10. Release of copper from roofs and roads in the basins of Mill and Thornton Creeks during storm events, the total copper loading during the storm event, and the ratio of release to loadings for each event.

[Ecology mg/VMT = 1.01 mg/VMT for all roads. Alternative mg/VMT = 0.03 mg/VMT for controlled access and 0.59 mg/VMT for arterials. **Abbreviations:** d, day; mg, milligrams; VMT, vehicle miles traveled; cm, centimeters; g, grams; m<sup>3</sup>, cubic meters; µg/L, micrograms per liter; < less than; > grater than]

Estimated Releases														
Date(s) of Sampling	Duration of Storm (days)	Antecedent Period (d)	Road Loadings (grams of total copper)		Roof Sources		Duration of hydrograph (d)	Total Volume of Hydrograph (m <sup>3</sup> )	Total Storm Volume (m <sup>3</sup> )	% of water retained by watershed	Copper Event Loading		Percentage of estimated releases not discharged by creeks during the storm event	
			Ecology mg/VMT	Alternative mg/VMT	Rainfall (cm)	Event Loading (g)					Total Copper Concentration (µg/L)	Stream Event Loading (g/event)	Ecology mg/VMT	Alternative mg/VMT
Mill Creek														
8/29-31/2005	2	11	6972	3058	0.73	1648	2	20655	149743	86	0.94 - 13.6	126	99	97
9/29/2005	2	15	9295	4077	1.08	2445	2	31074	222222	86	0.89 - 14.1	153	99	98
12/19/2005	2	17	10457	4587	1.07	2415	2	40119	219487	82	1.23 - 6.01	110	99	98
Median	—	15	9295	4077	1.07	2415	—	31074	219487	86	4.8	126	99	98
Thornton Creek														
Short storms (1-2 days) with short antecedent periods (< week) sorted by total rainfall														
9/13/2004	1	1.7	2300	515	0.66	1116	1.1	35584	196779	82	4.76	169	95	90
5/26/2004	1	2.7	3680	824	0.56	958	1.2	25101	168810	85	12.7	319	93	82
12/7/1998	1	4.0	5520	1236	1.24	2103	1.1	48427	370583	87	5.41	262	97	92
11/12/2002	1	2.0	2760	618	1.02	1734	0.9	32948	305656	89	15.1	498	89	79
2/29/2000	1	2.0	2760	618	1.44	2448	1.1	59948	431514	86	7.05	423	92	86
6/12/2000	1	4.0	5520	1236	1.57	2675	1.9	58332	471469	88	11.1	647	92	83
8/20/2008	2	1.0	2760	618	2.32	3950	2.1	80088	696217	88	7.09	568	92	88
2/1/2000	1	6.0	8280	1854	2.05	3485	1.7	129155	614309	79	11.6	1498	87	72
1/9/2006	1	1.0	1380	309	2.37	4025	0.9	51217	709452	93	4.22	216	96	95
6/24/1999	1	1.3	1840	412	2.77	4704	1.2	55194	829067	93	5.95	328	95	94
11/8/2000	1	2.0	2760	618	2.64	4494	1.0	77440	792109	90	7.2	558	92	89
6/11/2001	1	4.0	5520	1236	3.13	5316	0.9	75564	936946	92	9.89	747	93	89
11/9/1999	2	2.0	4140	927	4.07	6914	1.0	96676	1218629	92	7.54	729	93	91
9/18/2006	2	3.7	6440	1442	1.49	2529	1.8	50670	445748	89	6.87	348	96	91
4/30/2001	2	6.7	10581	2370	1.15	1961	2.1	56685	345611	84	12.8	726	94	83
Short storms (1-2 days) with long antecedent periods (> week)														
10/28/1998	1	9.3	12881	2885	1.97	3344	2.1	65790	589337	89	4.65	306	98	95
6/3/2008 <sup>1</sup>	1	13.0	17941	4018	2.38	4047	2.0	114161	713197	84	36.5	4167	81	48
9/18/1998	1	32.7	45082	10097	0.23	385	0.8	13399	67924	80	7.18	96	100	99
5/21/2007	2	6.5	10351	2318	2.72	4625	1.6	69822	815083	91	6.09	425	97	94
8/11/2009	2	36.0	51063	11436	1.12	1899	2.0	40266	334623	88	13.4	540	99	96
Moderate storms (2-3 days) with short antecedent period (< week)														
1/18/2005	3	4.0	8280	1854	3.72	6331	3.0	236116	1115744	79	4.53	1070	93	87
2/24/1999	3	2.0	5520	1236	5.07	8615	1.8	155528	1518291	90	5.44	846	94	91
12/6/1999	2	2.0	4140	927	2.43	4137	2.2	126471	729179	83	6.4	809	90	84
5/5/2009 <sup>1</sup>	2	2.0	4140	927	3.71	6314	3.0	274132	1112748	75	13.1	3591	66	50
10/31/2005	3	1.0	4140	927	2.96	5027	1.6	53971	886003	94	5.43	293	97	95
3/11/2002	3	1.3	4600	1030	3.34	5679	2.4	137758	1000874	86	8.43	1161	89	83
Moderate storms (2-3 days) with long antecedent period (< week)														
5/27/1998	3	7.7	13341	2988	3.73	6348	3.8	197996	1118741	82	6.95	1376	93	85
12/15/2009	2	14.0	20701	4636	3.36	5704	1.7	84334	1005369	92	4.6	388	99	96
Large multi-day storms														
11/14/2001	4	7.7	14721	3297	8.22	13970	3.8	340086	2462229	86	8.23	2799	90	84
3/16/2009	4	6.0	12421	2782	2.48	4217	4.0	127335	743164	83	2.82	359	98	95
1/27/2003	7	7.7	18861	4224	6.48	11023	7.2	359256	1942814	82	3.17	1139	96	93
11/7/2006	8	3.5	14491	3245	14.64	24883	6.6	466805	4385565	89	6.62	3090	92	89
Median		3.8	5520	1236	2.46	4177	1.8	76502	736172	87	7.00	563	93	89

Table A11. Summary of precipitation data in Thornton Creek basin: total event rainfall, maximum storm intensity and antecedent periods of 32 storms in North King County between 1998 and 2009.

[Abbreviations: cm/hr, centimeters per hour; cm, centimeters; cm/day, centimeters per day; SEATAC, Seattle-Tacoma International Airport; Mar., March; Nov., November; —, not available]

		Storm Event						Previous storm greater than 0.13 cm/day					
		Most intense rainfall (cm/hr)	Observed total event rainfall observed (cm)					Most intense rainfall (cm/hr)	Antecedent Period (days)				
		North King County											
Date of Sampling	Duration of Storm (days)	SEATAC	SEATAC	Haller Lake	Boeing Creek	Brugger Bog	Green Lake	SEATAC	SEATAC	Haller Lake	Boeing Creek	Brugger Bog	Green Lake
Short storms (1-2 days) with short antecedent periods (< week) sorted by total rainfall													
		4.2 for 4-											
9/13/2004	1	0.3 on 9/13	day Storm	0.6	0.58	0.79	—	—	—	2	2	1	—
5/26/2004	1	0.28	1.27	0.5	0.58	0.61	—	0.05	4	3	4	1	—
12/7/1998	1 - 2	0.13	0.96	1.9	0.97	0.84	—	0.1	2	4	2	6	—
11/12/2002	1	0.1	1.55	1	1.07	0.99	—	0.48	1	2	2	2	—
2/29/2000	1	0.28	1.65	1.2	1.47	1.65	—	0.15	1	2	2	2	—
6/12/2000	1 - 2	0.28	2.82	1.7	1.6	1.42	—	0.1	1	4	4	4	—
8/20/2008	2	0.41	1.83	2.8	1.93	2.24	—	0.38	9	1	1	1	—
				Storm record- ed on						Storm record- ed on			
2/1/2000	1 - 2	0.38	4.6	Feb. 2	2.2	1.9	—	0.1	6	Feb. 2	6	6	—
1/9/2006	1	0.3	2.92	3.6	2.21	2.21	1.45	0.15	1	1	1	1	1
6/24/1999	1 - 2	0.97	3.3	3	2.4	2.9	—	0.05	1	1	2	1	—
11/8/2000	1	0.51	2.16	2.6	2.49	2.84	—	0.1	2	2	2	2	—
6/11/2001	1	0.48	2.57	2.7	3.43	3.25	—	0.18	1	2	2	8	—
11/9/1999	2	0.36	2.7	2.8	5.2	4.2	—	0.25	2	2	2	2	—
9/18/2006	2 day into 9/18	0.25	1.37	1.4	1.37	1.3	1.88	0.1	3	4	4	3	—
Short storms (1-2 days) with long antecedent periods (> week)													
10/28/1998	1	0.36	0.69	2.4	1.6	1.9	—	0.18	10	3	12	13	—
6/3/2008	1 - 2	0.41	2.13	1	—	3.76	—	0.41	9	13	—	—	—
9/18/1998	1	0.28	0.35	0.3	0.2	0.18	—	0.08	33	32	33	33	—
5/21/2007	2-day	0.51	2.21	2.1	3.45	3.12	2.21	0.13	16	8	2	2	14
8/11/2009	2 day	0.3	1.14	—	0.97	1.24	1.14	0.08	47	—	28	28	52
Moderate storms (2-3 days) with short antecedent period (< week)													
1/18/2005	3	0.61	7.92	3.6	3.63	3.94	—	0.08	1	9	1	2	—
2/24/1999	3	0.43	4.5	3.1	6.8	5.3	—	0.13	3	2	3	1	—
12/6/1999	2 - 3	0.38	1.9	1.9	2.6	2.8	—	0.33	2	3	1	2	—
5/5/2009	2 - 3 storm	0.41	4.67	—	3.02	3.45	4.67	0.46	2	—	2	2	2
10/31/2005	day into 11/1	0.3	4.29	2.6	2.97	3.3	—	0.03	1	1	1	1	—
3/11/2002	into Mar. 12	0.36	3.96	4.2	2.72	3.1	—	0.1	1	2	1	1	—
Moderate storms (2-3 days) with short antecedent period (< week)													
5/27/1998	3 - 4	—	—	3.5	2.4	5.3	—	—	—	7	10	6	—
12/15/2009	2 - 3 storm	0.2	3.1	—	3.15	3.56	—	0.25	13	—	10	18	—
Large multi-day storms													
11/14/2001	into Nov. 15	0.74	11.28	8.6	8	8.05	—	0.05	1	7	8	8	—
3/16/2009	End of 4 day	0.33	4.47	2.5	1.42	1.52	4.48	0.56	5	8	5	6	5
	Tail end of 7-day												
1/27/2003	storm	0.91	8.99	8.1	5.89	5.46	—	0.03	8	7	8	8	—
Towards end of 7-9													
11/7/2006	day storm	1.1	25.1	15.6	14.5	13.64	14.8	0.41	4	4	4	4	2

Table A12. Average daily traffic, length of road segments and average daily miles traveled of Seattle arterials in the Thornton Creek watershed.

[Abbreviations: Hwy, highway; S, South; St., street; Pl, Place, R., River; N, North; W, West; SE, Southeast; Rd, Road; Dr, Drive; I, Interstate; SR, State ]

Segment	Intersection in which road segment begins	Intersection in which road segment begins	Length of line segment (miles)	Average daily traffic for segment	Average daily miles traveled
				TOTAL	
LAKE CITY WAY NE	NE 95th St	NE 145th St	2.619	36,332	95,165
MERIDIAN AVE N	N Northgate Way	N 122nd St	0.550	7,948	4,370
MERIDIAN AVE N	N 145th St	N 130th St	0.294	3,617	1,064
LAKE CITY WAY NE	NE 95th St	NE 81st St	0.744	33,403	24,866
N NORTHGATE WAY	Ashworth Ave N	I-5	0.549	27,160	14,902
NE NORTHGATE WAY	1st Ave NE	3rd Ave NE	0.124	31,332	3,878
NE NORTHGATE WAY	3rd Ave NE	5th Ave NE	0.122	22,952	2,810
NE NORTHGATE WAY	5th Ave NE	Roosevelt Way NE	0.250	23,999	5,997
NE NORTHGATE WAY	Roosevelt Way NE	15th Ave NE	0.250	23,551	5,884
NE NORTHGATE WAY	15th Ave NE	Lake City Way NE	0.605	13,836	8,369
NE 125TH ST	15th Ave NE	Roosevelt Way NE	0.257	17,503	4,497
NE 125TH ST	15th Ave NE	27th Ave NE	0.627	17,481	10,965
NE 125TH ST	27th Ave NE	30th Ave NE	0.128	14,182	1,818
NE 125TH ST	30th Ave NE	35th Ave NE	0.245	13,063	3,201
NE 125TH ST	35th Ave NE	Sandpoint Way	0.209	10,509	2,193
NE 130TH ST	Lake City Way NE	35th Ave NE	0.104	5,139	535
NE 130TH ST	Roosevelt Way NE	15th Ave NE	0.238	15,499	3,692
NE 130TH ST	30th Ave NE	20th Ave NE	0.504	2,926	1,475
NE 145TH ST	5th Ave NE	15th Ave NE	0.512	28,318	14,509
NE 145TH ST	15th Ave NE	30th Ave NE	0.748	25,733	19,257
NE 145TH ST	Lake City Way NE	30th Ave NE	0.183	17,836	3,273
PINEHURST WAY NE	NE 115th St	NE 117th St	0.168	8,173	1,375
PINEHURST WAY NE	NE 115th St	Roosevelt Way NE	0.187	9,455	1,773
RAVENNA AVE NE	Lake City Way NE	NE 98th St	0.364	4,722	1,721
RAVENNA AVE NE	NE 98th St	NE 105th St	0.353	1,774	626
ROOSEVELT WAY NE	NE 130th St	5th Ave NE	0.336	19,223	6,451
ROOSEVELT WAY NE	NE 130th St	NE 115th St	0.518	11,403	5,904
ROOSEVELT WAY NE	NE 115th St	NE Northgate Way	0.237	6,160	1,461
ROOSEVELT WAY NE	NE Northgate Way	NE 92nd St	0.871	9,677	8,429
SAND POINT WAY NE	NE 89th St	103rd	0.597	12,117	7,238
COLLEGE WAY N	N 95th St	97th	0.157	6,740	1,061
NE 103RD ST	1st Ave NE	5th Ave NE	0.244	6,329	1,547
NE 110TH ST	Lake City Way NE	35th Ave NE	0.483	3,012	1,455
NE 115TH ST	Lake City Way NE	35th Ave NE	0.396	2,528	1,000
NE 115TH ST	Lake City Way NE	Pinehurst Way NE	0.710	4,080	2,897
NE 115TH ST	Roosevelt Way NE	Pinehurst Way NE	0.119	2,104	251
15TH AVE NE	Lake City Way NE	NE Northgate Way	1.352	8,316	11,246
15TH AVE NE	NE Northgate Way	NE 117th St	0.372	7,336	2,731
15TH AVE NE	NE 117th St	NE 120th St	0.119	12,224	1,457
15TH AVE NE	NE 120th St	NE 125th St	0.256	14,913	3,816
15TH AVE NE	NE 125th St	NE 145th St	1.004	14,533	14,596
1ST AVE NE	NE 145th St	Roosevelt Way NE	0.539	5,012	2,702
1ST AVE NE	NE Northgate Way	NE 103rd St	0.365	15,608	5,690
1ST AVE NE	NE 100th St	NE 92nd St	0.384	6,778	2,602
30TH AVE NE	NE 145th St	NE 130th St	0.738	6,436	4,751
30TH AVE NE	NE 130th St	NE 125th St	0.236	7,373	1,738
35TH AVE NE	NE 130th St	NE 145th St	0.741	13,099	9,711
35TH AVE NE	NE 130th St	NE 125th St	0.239	10,477	2,502
35TH AVE NE	NE 125th St	NE 115th St	0.493	11,955	5,896
35TH AVE NE	NE 115th St	NE 82nd St	1.635	12,473	20,393
Sum of average daily vehicle miles traveled in Thornton Creek, Shoreline					365,741

Table A13. Average daily traffic, length of road segments and average daily miles traveled of Shoreline arterials in the Thornton Creek watershed.

[**Abbreviations:** AWDT, average weekday traffic, Hwy, highway; S, South; St., street; Pl, Place, R., River; N, North; W, West; SE, Southeast; Rd, Road; Dr, Drive]

Street	Length of line segment (miles)	AWDT (2005)	AWDT (2006)	AWDT (2007)	AWDT (2008)	AWDT (2009)	Average AWDT for segment TOTAL	Average Daily Miles Traveled
1st Ave NE	0.164	31,668	31,668	31,668	31,668	31,668	31,668	5,208
Meridian Ave N	0.250	27,673	27,673	27,673	27,673	27,673	27,673	6,927
Lenora	0.430	25,016	25,016	25,016	25,016	25,016	25,016	10,763
Meridian Ave N	0.345	13,331	11,551	11,551	11,484	11,484	11,880	4,104
I-5	0.230	12,205	11,481	11,103	11,635	11,635	11,612	2,676
5th Ave NE	0.222	12,004	10,929	9,902	9,902	9,902	10,528	2,335
11th Ave NE	0.251	10,233	9,172	8,717	9,317	9,317	9,351	2,343
15th Ave NE	0.250	8,684	7,624	7,391	7,391	7,226	7,663	1,919
Meridian Ave N	0.328	23,122	23,122	23,122	22,213	22,213	22,758	7,468
I-5	0.230	32,661	31,632	32,249	31,781	32,252	32,115	7,395
5th Ave NE	0.219	18,936	17,991	18,471	17,934	17,793	18,225	3,988
15th Ave NE	0.498	15,534	14,351	14,389	14,389	14,002	14,533	7,244
N 155th St	0.489	7,814	7,653	7,653	6,377	6,142	7,128	3,488
N 167th St	0.625	8,916	10,187	10,187	10,187	10,187	9,933	6,204
N 175th St	0.366	11,619	10,187	11,644	10,135	10,039	10,725	3,920
N 185th St	0.492	12,077	12,077	12,077	12,065	12,065	12,072	5,942
N 192nd St	0.343	10,687	10,870	11,198	11,198	11,198	11,030	3,778
Meridian Ave N	0.380	11,963	11,963	11,963	11,218	11,218	11,665	4,432
1st Ave N	0.248	9,455	9,455	9,455	10,236	10,236	9,767	2,418
11th Ave NE	0.109	7,102	8,015	7,148	7,196	7,196	7,331	802
NE 175th St	0.245	17,724	15,246	15,038	15,038	15,038	15,617	3,821
NE 165th St	0.498	16,156	16,578	16,743	16,114	15,473	16,213	8,073
NE 155th St	0.484	14,126	14,306	15,643	15,643	15,643	15,072	7,288
NE 145th St	0.495	16,984	16,503	16,649	16,649	16,649	16,687	8,261
Total of average weekday vehicle miles traveled in Thornton Creek, Shoreline								120,794
Total of average daily vehicle miles traveled in Thornton Creek, Shoreline <sup>1</sup>								112,701

1) Use value of 0.933 for the ratio of average daily traffic to average weekday traffic.

Table A14. Average daily traffic, length of road segments and average daily miles traveled of controlled access Interstate 5 in the Thornton Creek watershed.

[Abbreviations: ADT, average daily traffic; St, street; NB, northbound; --, not applicable]

Ramp in which highway segment begins	Ramp in which highway segment ends	Length of line segment (miles)	ADT (2006)	ADT (2007)	ADT (2008)	ADT (2009)	Average ADT for segment TOTAL	ADT*I
89th St	Northgate Way NB off ramp	1.226	--	210,000	203,000	204,000	205,667	252,159
Northgate Way NB off ramp	145th St NB off ramp	1.452	--	200,333	194,000	196,333	196,889	285,915
145th St NB off ramp	145th St NB on ramp	0.316	180,000	175,000	170,000	172,000	174,250	55,074
145th St NB on ramp	175th St NB off ramp	1.253	198,500	194,500	188,500	190,500	193,000	241,819
175th St NB off ramp	175th St NB on ramp	0.34	--	175,000	169,000	171,000	171,667	58,433
Sum		4.588						893,399