Mercury and Copper Levels in Leach Creek (Pierce County) During 2009-2010

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Cover photo: USGS gaging station 12091200, Leach Creek near Fircrest.
(photo: U.S. Geological Survey)

Mercury and Copper Levels in Leach Creek (Pierce County) During 2009-2010

by

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Waterbody Number:
WA-12-1110 Chambers Creek

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Abstract

The Washington State Department of Ecology (Ecology) detected several instances of elevated mercury concentrations at the mouth of Leach Creek in Tacoma during routine water quality monitoring in 2007-2008.

Ecology conducted a follow-up study to better characterize mercury levels in the creek and assess specific reaches as sources during monthly monitoring from September 2009 through August 2010 at four locations. An effort was made to collect samples during stormwater runoff events. Copper was also analyzed in view of concerns about its potential impact to salmon.

Water quality violations were detected for both mercury and copper in Leach Creek. Total mercury exceeded (did not meet) the Washington State chronic water quality criterion during four sampling events. The chronic criterion for dissolved copper was exceeded during two sampling events, one of which also had an exceedance of the acute criterion. Sources appear to lie towards the upstream end of the Leach Creek watershed.

It is recommended that Leach Creek be placed in Category 5 (303(d) list) of the state Water Quality Assessment as being water quality limited for mercury and copper.

Acknowledgements

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- City of Tacoma, Public Works, Environmental Services/Science & Engineering, assisted with the study. Special thanks to Dana B. de Leon, Chris Burke, Lorna Mauren, and Jeffrey McVicker.
- Cindy James, Ecology's Water Quality Program, Southwest Regional Office, originally proposed the study.
- Ecology Environmental Assessment Program staff:
  - Manchester Environmental Laboratory analyzed project samples. Special thanks to Dean Momohara's Inorganic Chemistry Unit, Nancy Rosenbower, and Leon Weiks.
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  - Joan LeTourneau and Cindy Cook formatted the final report.

Introduction

Mercury

Leach Creek is a highly urbanized tributary to lower Chambers Creek in west-central Tacoma, located within the Chambers/Clover Creek watershed (Figure 1). Ambient monitoring by the Washington State Department of Ecology (Ecology) Freshwater Monitoring Unit (FMU) detected elevated levels of mercury in December 2007 and February and August of 2008 (Table 1).

Table 1. Ecology Ambient Monitoring Data for Mercury at the Mouth of Leach Creek, 2007-08.

Date	Flow	Total Mercury	Turbidity	TSS
	(cfs)	(ug/L)	(NTU)	(mg/L)
10/31/2007	8.5	<0.002	0.5	1
12/19/2007	59	**0.012**	19	86
2/27/2008	12	**0.007**	6.8	25
4/23/2008	10	<0.002	2.4	3
6/18/2008	~8.5	<0.002	1.5	2
8/20/2008	>14	**0.037**	55	191

TSS = total suspended solids.
ug/L = parts per billion.

For protection of aquatic life, Washington State's chronic and acute water quality criteria for mercury are 0.012 ug/L (total) and 2.1 ug/L (dissolved), respectively (WAC 173-201A). Leach Creek mercury levels were at or above the chronic criterion in December 2007 and August 2008, and above detection limits (0.002 ug/L) in February 2008. An Ecology study in 1995 (Johnson, 1996) reported elevated mercury concentrations in wet weather samples from Leach Creek (0.018 - 0.034 ug/L). The 1995 study resulted in a 303(d) listing for the downstream segment of Leach Creek.

Section 303(d) of the federal Clean Water Act requires states to prepare a list of waterbodies that do not meet water quality standards. 303(d) listing requires that at least two samples do not meet (exceed) the water quality criterion in a three-year period. Although the elevated mercury results in Leach Creek are unusual, the ambient data from 2007-08 did not meet the 303(d) requirement because only one sample actually exceeded the criterion.

FMU's annual report for Water Year 2008 recommended that "additional monitoring should be conducted to confirm mercury in Leach Creek" (Hallock, 2009). Ecology's Southwest Regional Office, Water Quality Program, requested an investigation to follow up on this recommendation.

Copper

Copper is an important nonpoint-source pollutant in urbanized areas of Puget Sound. Considerable research has been devoted to evaluating the effects of dissolved copper on both juvenile and adult salmon (McIntyre et al., 2008). Leach Creek is a tributary of Chambers Creek, and since Chambers/Clover Creek is used by salmon, copper concentrations were also measured as part of this 2009-10 study.

There have not been any previous reports of copper exceeding water quality criteria in Leach Creek or other parts of the Chambers/Clover Creek watershed. Ecology's routine monitoring data for Leach Creek showed dissolved copper concentrations of 0.48 - 2.4 ug/L in 2007-08. The maximum dissolved copper concentration reported in Ecology's 1995 study was 3.8 ug/L in Leach Creek, with lower concentrations in Chambers Creek and Clover Creek (Johnson, 1996). The acute and chronic aquatic life criteria for dissolved copper are 17 and 11 ug/L, respectively (at 100 mg/L hardness).

It has been documented that copper affects juvenile salmonids at lower concentrations than the water quality criteria. Low-level copper effects to juvenile salmonids include, but are not limited to, impaired olfactory function and predator avoidance, as well as reduced growth. Low concentrations of dissolved copper can be highly toxic to invertebrates which are the primary food source for juvenile salmonids. (Hecht et al., 2007.)

Project Description

Mercury and copper concentrations were monitored at four locations in Leach Creek from September 2009 through August 2010. The objectives were to (1) better characterize mercury and copper concentrations in the creek and (2) determine if certain reaches have significant sources of these metals. The monitoring program was timed to include stormwater runoff events.

Ecology's Environmental Assessment Program conducted the study. Ecology's Manchester Environmental Laboratory (Manchester) analyzed the samples. Field procedures and laboratory analysis met requirements for 303(d) listing, as described in Water Quality Program Policy 1-11.

Figure 1 is a map of the monitoring sites on Leach Creek.

Figure 1. Monitoring Sites for Mercury and Copper in Leach Creek, 2009-10.

Watershed Description

The following description of the Leach Creek watershed is from the City of Tacoma, Surface Water Management Manual, September 22, 2008 edition (Tacoma, City of, 2008):

> *"Leach Creek has a drainage area of approximately 6.5 square miles. Land use is residential and commercial. Included in this watershed is a portion of Westgate Shopping Center, James Center, Highland Hills Shopping Center, and Tacoma Community College. A portion of the Tacoma Landfill Superfund site is also included in this watershed. China Lake is also a part of the watershed.*
>
> *Leach Creek is a little over 2 miles long. Salmonid spawning habitat can be found from Chambers Creek up to Bridgeport Way (the lower portion of the Creek). The upper portions of the Creek also have pockets of spawning grounds; however, the elimination of vegetation and channelization by streamside homeowners and erosion during storm events has impacted these areas. Leach Creek flows into Chambers Creek just downstream of the confluence of Flett and Chambers Creek. Chambers Creek is a fish bearing creek and there are two fish hatcheries located on the creek.*
>
> *Stormwater within the watershed is piped to the Leach Creek Holding Basin, which discharges into Leach Creek. The cities of Tacoma and Fircrest discharge to the holding basin. The Leach Creek Holding Basin was constructed by the City of Tacoma in 1961. During heavy rainfall events, stormwater is pumped from the holding basin into the Thea Foss drainage basin to avoid sending high flows to Leach Creek. The City also uses the Holding Basin to augment the flow in the Creek during periods of low flow as part of current Landfill remediation efforts."*

Previous efforts by the City of Tacoma to track metals sources have encountered difficulty identifying individual sources. Dana de Leon, of the City of Tacoma Public Works, has cautioned that, although elevated mercury or copper levels may be detected in this study, it may not lead to finding point sources. Public Works has cleaned sediments out of entire stormwater basins where mercury was of concern but still has seen mercury reappearing in the basin. They have concluded that, due to the large number of historic and everyday sources, the "chemistry is smeared over entire watersheds." (Dana de Leon, 5/22/09 email)

Existing Monitoring Stations

The U.S. Geological Survey (USGS) has operated a stream gaging station on Leach Creek since 1957(USGS station 12091200 Leach Creek near Fircrest). Monthly mean flow at this site is shown in Figure 2. Low streamflows of 2-3 cubic feet per second (cfs) typically occur in July through September. The highest flows are in November through February: 7-10 cfs on average. The City of Tacoma also monitors flow at the outlet from the Leach Creek Holding Basin.

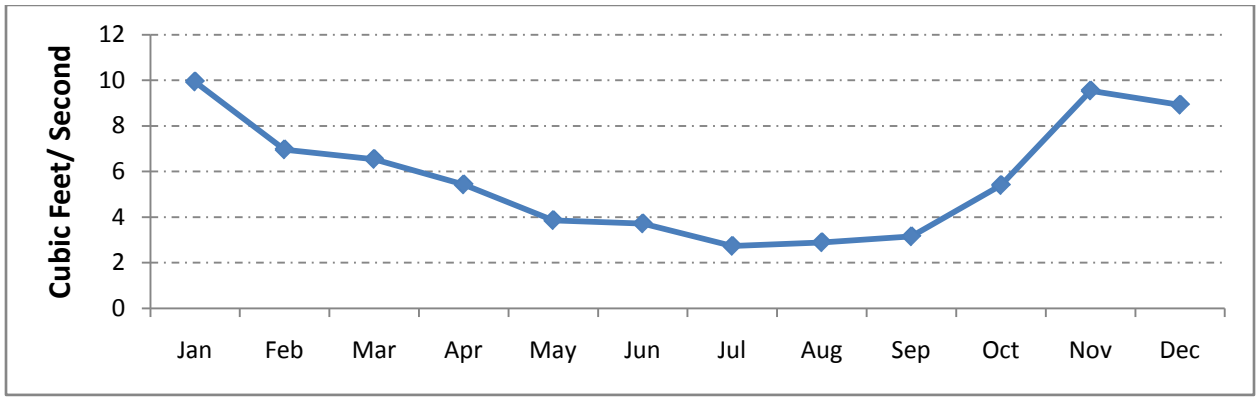

Figure 2. Monthly Mean Discharge (cfs) at Leach Creek, 1989-2008.

Ecology's routine water quality monitoring station is near the mouth of Leach Creek at Bridgeport Way (Ecology Station 12B070 - Leach Creek near Steilacoom). Water samples have been collected at this site during 1964-65, 1973, and 2007-08. Metals data are limited to 2007-08.

Sampling Design

Ecology's 2007-08 ambient monitoring data indicated that mercury concentrations in lower Leach Creek are correlated with streamflow, turbidity, and total suspended solids (R^2= 0.89-0.97)[1]. For both mercury and copper, the highest concentrations detected in Ecology's 1995 study occurred during wet weather. Stormwater runoff events were thus implicated.

Many storm drains discharge into Leach Creek throughout its length, from the Holding Basin to the mouth. It was not practical to monitor all these discharges, nor was there a basis for selecting a subset of the drains as potential metals sources. Therefore, the present 2009-10 study attempted to determine if specific reaches of the creek could be isolated as having significant sources of mercury or copper.

Monthly monitoring was conducted from September 2009 through August 2010 at four sites on the mainstem (Figure 1 and Table 2):

Table 2. Sampling Site Coordinates.

Sampling Site	Latitude	Longitude
Holding Basin Outlet	47.22481	-122.50922
Emerson Street (USGS Gage Station)	47.22126	-122.50946
56th Street	47.20626	-122.51499
Bridgeport Way (Ecology Ambient Monitoring Station)	47.19818	-122.52316

These locations were selected in consultation with the City of Tacoma, Public Works. To the extent practical, sampling was timed to coincide with stormwater runoff events to include higher flows such as those sampled by Ecology in 2007-08.

All samples consisted of simple grabs. During runoff events, an effort was made to catch the early part of the storm when turbidity and total suspended solids are typically highest. A total of 48 samples were collected, 12 from each monitoring site. The samples were analyzed for mercury, copper, hardness, turbidity, and conductivity. Mercury and copper were analyzed as total and dissolved, respectively, for comparison with Washington State water quality criteria. Streamflow measurements were obtained from USGS, the City of Tacoma, or at the time of sample collection.

Clean sampling techniques and low-level laboratory methods were used for mercury and copper to better establish compliance with the water quality criteria. The reporting limits were 0.002 ug/L for mercury and 0.10 ug/L for copper.

[1] R^2, the coefficient of determination, is a number from 0 to 1 which indicates the strength of a relationship between two variables. The closer R^2 is to 1, the stronger the relationship.

Methods

Field Procedures

Table 3 shows the sample size, container, preservation, and holding time for each study parameter. Manchester Laboratory provided the sample containers.

Table 3. Sample Containers, Preservation, and Holding Time.

Parameter	Container	Preservation	Holding Time
Total Mercury	500 mL Teflon	HNO_3 to pH<2, $\leq 6^oC$	28 days
Dissolved Copper	500 mL Teflon	Filter, HNO_3 to pH<2, $\leq 6^oC$	6 months
Hardness	125 mL poly bottle	H_2SO_4 to pH<2, $\leq 6^oC$	6 months
Turbidity	500 mL poly bottle	Cool to $\leq 6^oC$	48 hours
Conductivity	500 mL poly bottle	Cool to $\leq 6^oC$	28 days

Sampling procedures for metals followed the guidance in EPA (1995) *Method 1669: Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels*. The mercury and copper samples were collected directly into pre-cleaned 500 mL Teflon bottles. Samples for dissolved copper were filtered in the field through a pre-cleaned 0.45 um Nalgene filter unit (#450-0045, type S). The filtrate was transferred to a new pre-cleaned 500 mL Teflon bottle.

The Teflon bottles and Nalgene filters were cleaned by Manchester, following standard operating procedure (SOP) 720005 v 3.0 and sealed in plastic bags. Personnel wore non-talc nitrile gloves when filtering the samples.

All samples were placed in plastic bags and held on ice for transport to Ecology headquarters, and then taken by courier to Manchester within 24 hours of collection. The metals samples were preserved to pH <2 on receipt at Manchester. Chain-of-custody procedures were followed.

Streamflow was obtained from the City of Tacoma (Holding Basin), the USGS (Emerson Street), or measured with a Marsh-McBirney meter and top-setting rod (56th Street, Bridgeport Way). A hand-held global positioning system was used to record sampling locations.

Laboratory Procedures

Manchester analyzed project samples using the methods shown in Table 4.

Table 4. Laboratory Procedures.

Parameter	Reporting Limit	Analytical Method
Mercury	0.002 ug/L	CVAA, EPA 245.7
Copper	0.1 ug/L	ICP/MS EPA 200.8
Hardness	0.3-1.5 mg/L	SM2340B
Turbidity	1 NTU	SM2310
Conductivity	0.5 umhos/cm	SM2510B

CVAA = Cold Vapor Atomic Absorption.
ICP/MS = Inductively Coupled Plasma/Mass Spectrometry.
SM = Standard Method.

Data Quality

Manchester Laboratory prepared written case narratives reviewing the quality of the data for this project. The reviews include an assessment of sample condition on receipt at the laboratory, compliance with holding times, instrument calibration, procedural blanks, laboratory control samples, matrix spike and matrix spike duplicate recoveries, and duplicate sample analyses. No significant problems were encountered that compromise the accuracy, validity, or usefulness of the data. The case narratives and complete chemical data for this project are available from the author.

The variability (field and laboratory) of the data reported here can be assessed from results on replicate field samples (Table 5). The replicates were separate samples collected approximately five minutes apart. Mercury and copper concentrations in the replicates agreed within 8% (relative percent difference, RPD), except for one mercury replicate at 35% RPD. Results for turbidity, hardness, and conductivity were also in close agreement (11% RPD or better).

Table 5. Precision on Replicate Samples.

Station	Sample Number	Date	Total Mercury (ug/L)	Diss. Copper (ug/L)	Turbidity (NTU)	Hardness (mg/L)	Conduct. (umhos/cm)
Bridgeport Way	0909056-04	9-Sep-09	0.0037	0.64	0.9	116	282
Bridgeport replicate	0909056-05	9-Sep-09	0.0026	0.63	1.0	115	282
		RPD =	35%	2%	11%	1%	0%
Emerson Street	1001067-04	25-Jan-10	0.0055	2.1	4.0	102	261
Emerson replicate	1001067-07	25-Jan-10	0.0051	2.2	4.3	103	250
		RPD =	8%	6%	7%	1%	4%
Holding Basin Outlet	1005021-01	18-May-10	0.0123	5.1	10	58	142
Holding Basin replicate	1005021-02	18-May-10	0.0125	4.8	9.3	61	140
		RPD =	2%	6%	7%	5%	1%

RPD = relative percent difference.

Two types of field blanks were analyzed to assess potential for metals contamination arising from sample containers or the filtration procedure. Manchester prepared the bottle blanks by filling the Teflon sample bottles with deionized water. Filter blanks were prepared by filtering the contents of a bottle blank. The field blanks were treated the same as samples.

Bottle and filter blanks were analyzed on three occasions during the project (Appendix B). Neither mercury nor copper was detected in the blanks at or above 0.002 ug/L and 0.10 ug/L, respectively. These results demonstrate that the sample collection, filtration, and preservation procedures were not contributing significant amounts of metals to the samples.

Results and Discussion

Rainfall and Streamflow

The Leach Creek watershed received 43 inches of rain during the 2009-10 study period, slightly more than the historical average of 39 inches. Precipitation was 30% above average in September 2009 and almost 50% higher during May and June 2010. Less than half the average rainfall was experienced in December 2009 (Figure 3). Precipitation data were collected at a monitoring station near Fife, Washington. (King County)

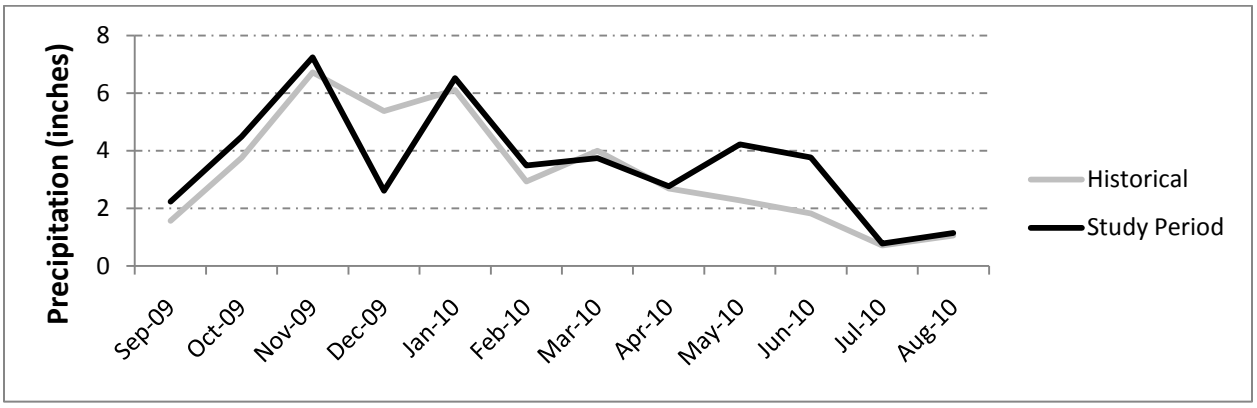

Figure 3. Mean Monthly Precipitation During 2009-10 Study Compared to 1997-10.

Discharge data are from the USGS station 12091200, Leach Creek near Fircrest. Monthly mean discharge was higher in November and lower in December than historical mean values. For the rest of the study period, discharge was similar to the historical average (Figure 4).

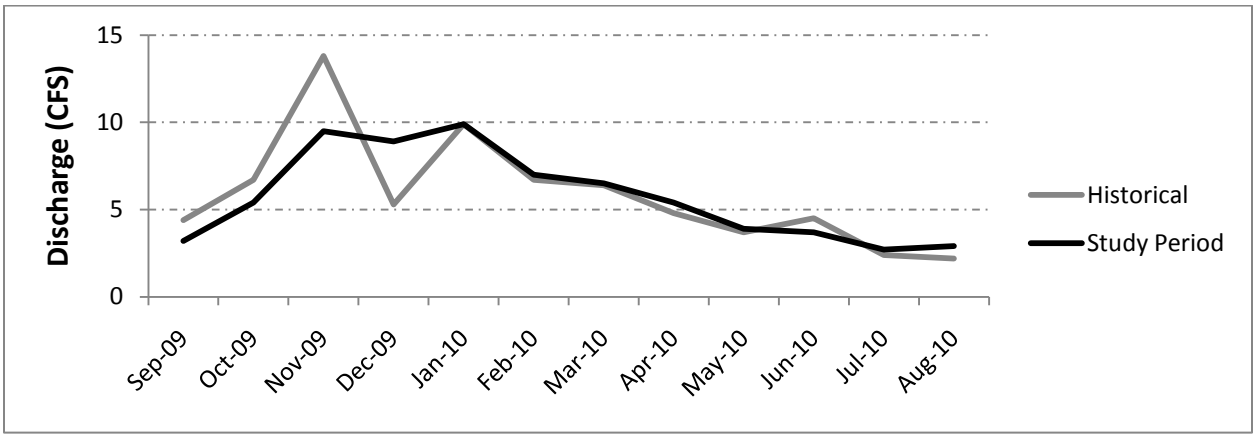

Figure 4. Mean Monthly Flow During 2009-10 Study Compared to Historical Flow (1989-2009).

Eight of the 12 sampling events were conducted on days with rising flow in Leach Creek. Samples collected in April, June, and July reflect relatively dry periods. During these months, there was little or no runoff entering the creek when samples were collected. Multiple samples were obtained during high flow, similar to the conditions during 2007-8 that resulted in an exceedance of the water quality criterion for mercury.

General Water Quality Parameters

Summary statistics for general water quality parameters measured during the current study are in Table 6. The complete set of project data can be found in Appendix A.

Table 6. Summary of Results for General Water Quality Parameters for Leach Creek. 2009-10 (N=48).

Parameter	Mean	Median	Minimum	90th %	Maximum
Turbidity (NTU)	6.3	4.0	0.9	16	18
Hardness (mg/L)	100	99	35	154	167
Conductivity (umhos/cm)	240	254	94	353	387

Turbidity in Leach Creek ranged from 0.9 to 18 nephelometric turbidity units (NTU). The median turbidity was 6.3 NTU. There was a trend toward decreasing turbidity moving downstream from the Holding Basin to Bridgeport Way (Figure 5).

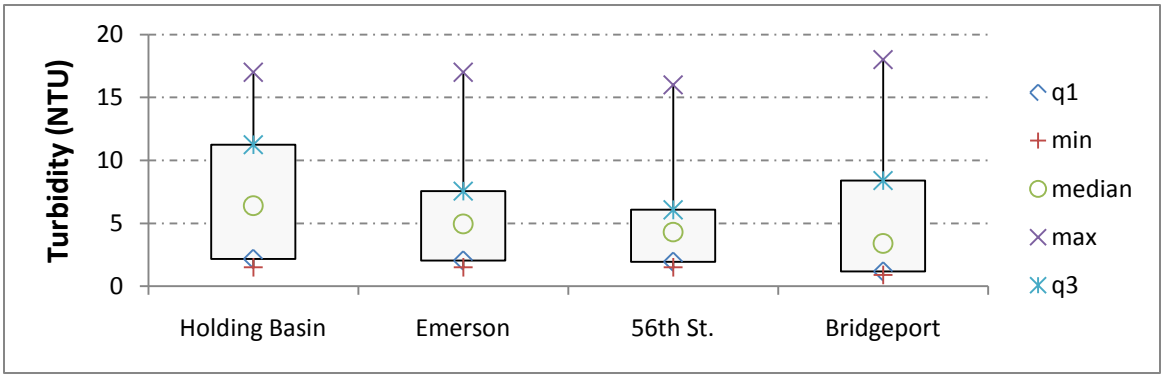

Figure 5. Boxplot for Turbidity in Leach Creek, 2009-10.

In these plots, the box encloses 75% of the data, i.e., between the first (q1) and third (q3) quartiles. (q1 = 25th percentile; q3 = 75th percentile.) Boxplots are a way to compare the distributions of several sets of data.

Figure 6 shows the turbidity measured during each sampling event. In most cases, turbidity was higher at the upstream sites (Holding Basin or Emerson Street). Because samples were collected in an upstream-to-downstream order, runoff impacts to the creek sometimes became more pronounced as the downstream sampling sites were reached. This effect is reflected in relatively higher turbidity at 56th Street and Bridgeport Way on certain occasions, e.g., November, May, and July.

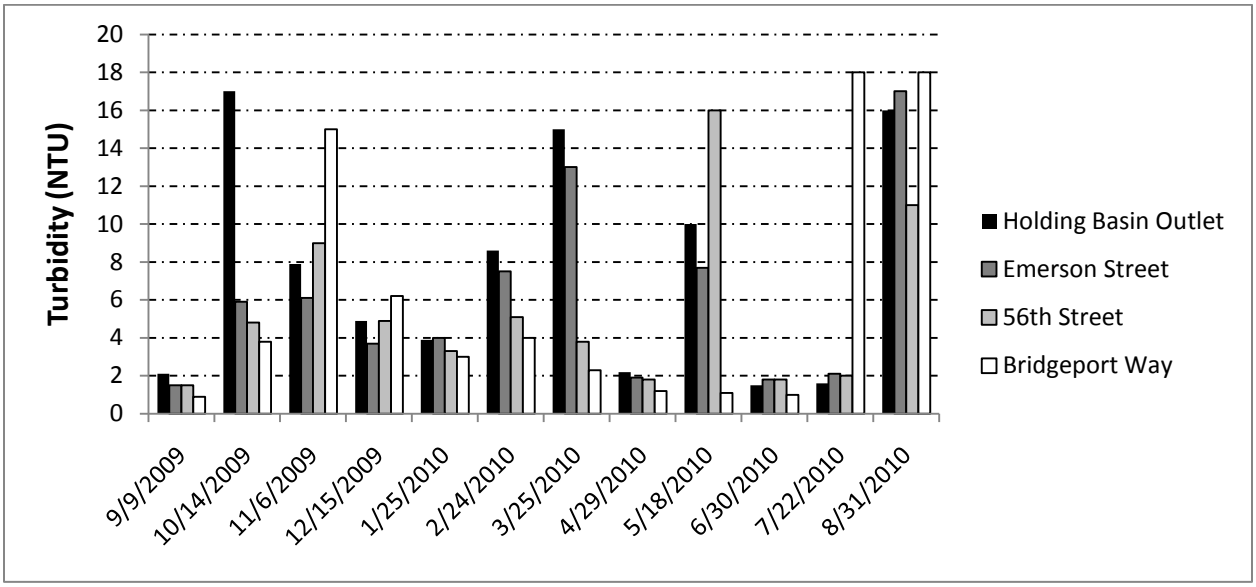

Figure 6. Turbidity at Leach Creek Sites.

Hardness was measured to compute the water quality criteria for copper at the time of sample collection. Hardness ranged from 35-167 mg/L. The average hardness was 100 mg/L.

Mercury and Copper

Summary statistics for mercury and copper in Leach Creek are in Table 6. The data are displayed by sampling site in Figures 7 and 8.

Table 7. Summary Statistics for Mercury and Copper in Leach Creek, 2009-10.

Station	Mean	Median	Minimum	90th %	Maximum
Total Mercury					
Holding Basin Outlet	0.0086	0.0080	0.002 U	0.0124	0.0235
Emerson Street	0.0073	0.0062	0.002 U	0.0106	0.0229
56th Street	0.0060	0.0055	0.002 U	0.0096	0.0123
Bridgeport Way	0.0057	0.0040	0.002 U	0.0132	0.0137
Dissolved Copper					
Holding Basin Outlet	3.36	2.54	0.52	5.08	12.9
Emerson Street	3.76	2.57	0.51	10.7	11.8
56th Street	1.74	1.24	0.56	3.04	5.96
Bridgeport Way	1.21	1.20	0.40	1.74	2.37

U= undetected at or above the reported value.

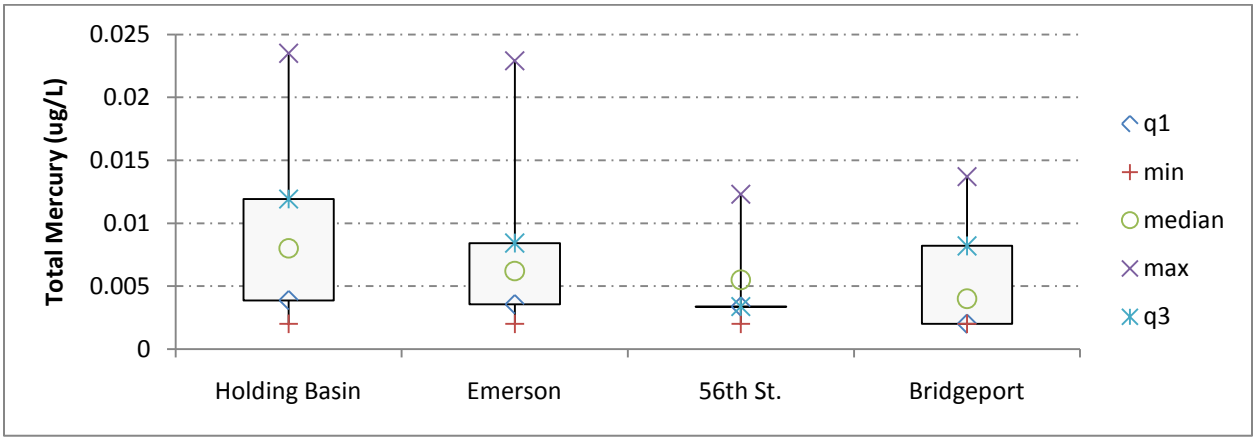

Figure 7. Boxplot for Leach Creek Mercury Results, 2009-10.

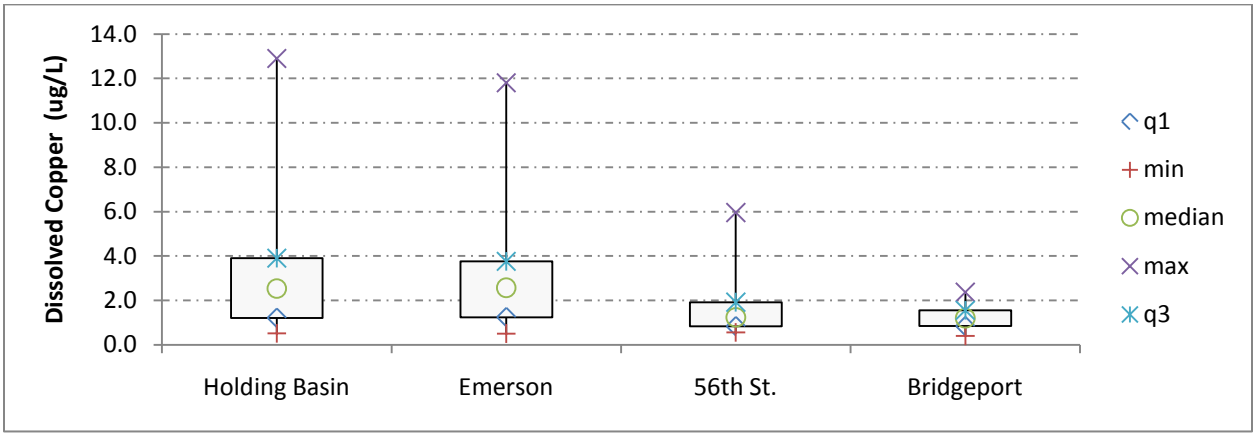

Figure 8. Boxplot for Leach Creek Copper Results, 2009-10.

Median metals concentrations showed a decreasing trend moving downstream. Figure 9 shows mercury concentrations for each sampling event. In most cases, the concentrations were higher at one of the upstream sites. When there was no significant surface runoff contributing to Leach Creek discharge, water samples had lower mercury concentrations of mercury. The samples with the highest mercury concentrations were collected during a first-flush runoff event on August 30, 2010. These samples were preceded by 59 days without enough precipitation to significantly increase the discharge of the creek.

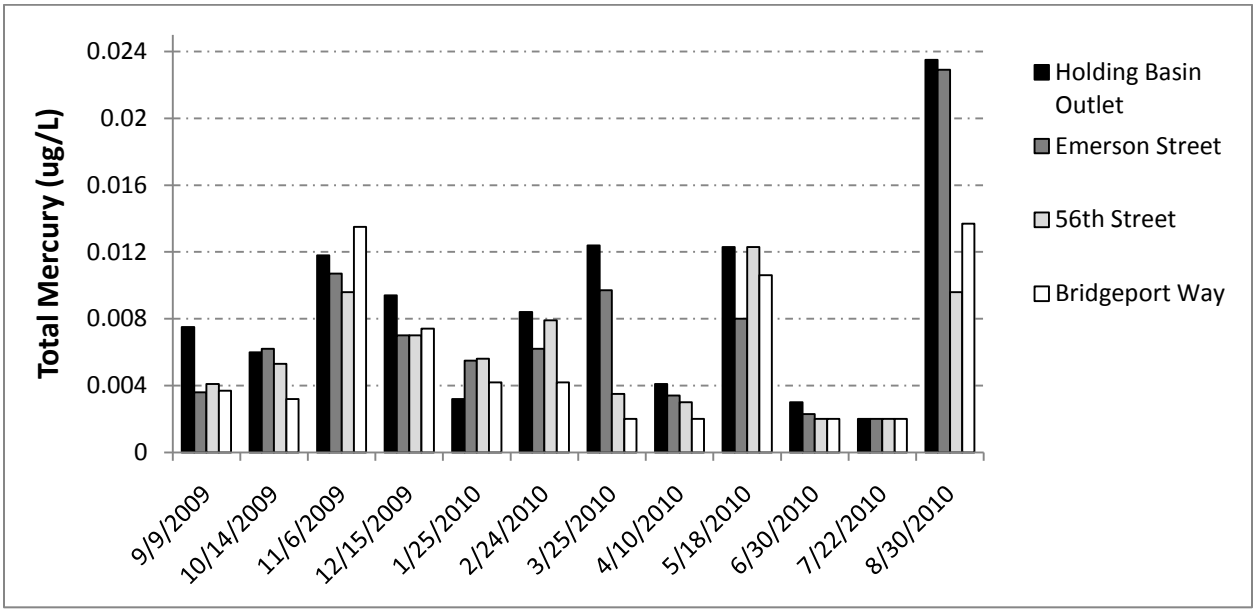

Figure 9. Mercury Concentrations in Leach Creek, 2009-10.

Copper exhibited a generally similar pattern (Figure 10). The higher levels were measured during runoff events after a period of dry weather (May and August). During periods of elevated concentrations, copper levels at the upstream sites were relatively greater than the downstream sites.

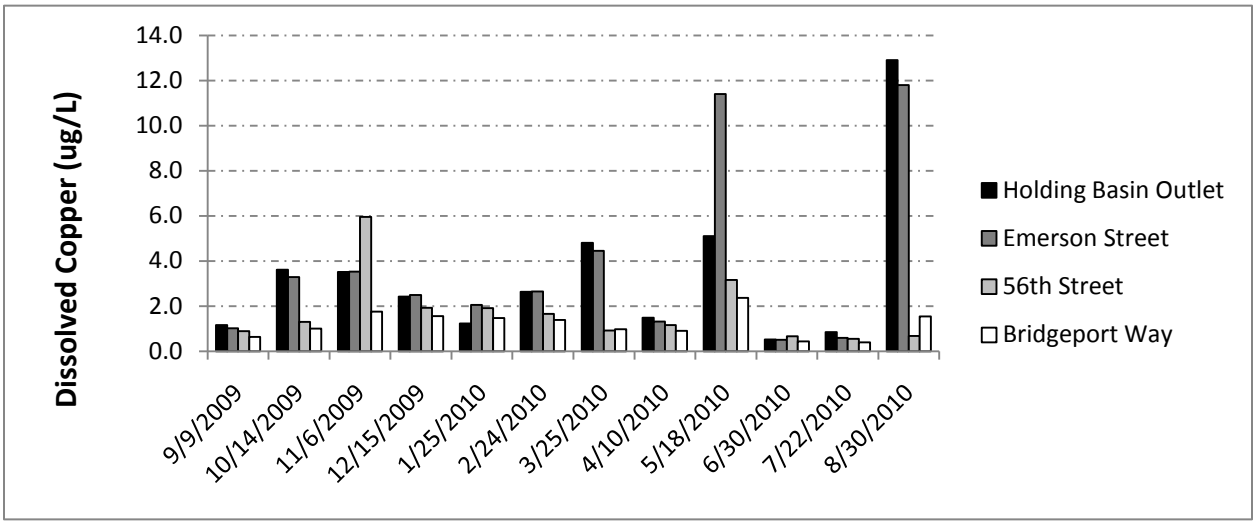

Figure 10. Dissolved Copper Concentrations in Leach Creek, 2009-10.

Higher concentrations of mercury and copper tended to be associated with turbidity generated during runoff events. There was a stronger correlation between turbidity and mercury (R^2=0.69) and, to a lesser extent, turbidity and copper (R^2=0.34). There was a weak correlation between flow and mercury concentration (R^2=0.13).

Comparison with Water Quality Criteria

Washington's water quality standards establish mercury and copper criteria for protection of aquatic life. As previously noted, the criteria for chronic and acute exposure to mercury are 0.012 and 2.1 ug/L, respectively. The chronic criterion is a 4-day average total concentration not to be exceeded more than once every three years on average. The acute criterion is a 1-hour average dissolved concentration not to be exceeded more than once every three years on average.

The chronic water quality criterion for mercury was exceeded in seven water samples collected on four different days (Figure 11). Five of the seven violations were less than 0.0017 ug/L (<2%) above the criterion. However, for 303(d) listing purposes, any value above the criteria constitutes a water quality violation (Niemi and Brown, 2011).

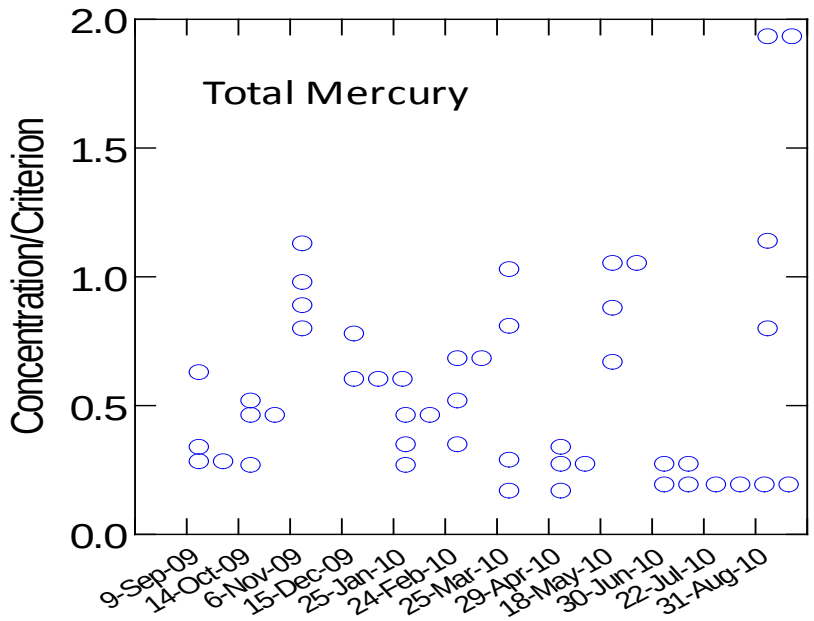

Figure 11. Mercury Concentration/ Chronic Criterion Ratios for Leach Creek, 2009-10.
Ratios > 1 exceed chronic water quality criterion; detection limit used for non-detects; acute criterion not exceeded.

The criteria for copper apply to the dissolved fraction and vary inversely with hardness. For the average hardness measured in Leach Creek during the study period (100 mg/L), the chronic and acute criteria for copper are 11 and 17 ug/L, respectively. Copper criteria were calculated using the hardness result associated with each sample. Figure 12 shows the four dissolved copper criteria exceedances (two acute and two chronic) observed during three sampling events.

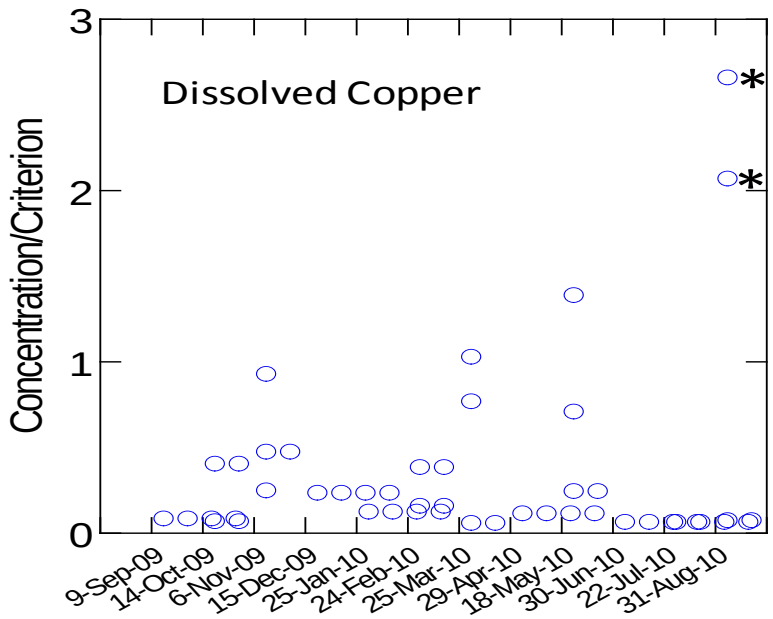

Figure 12. Copper Concentration/ Chronic Criterion Ratios for Leach Creek, 2009-10. *Ratios > 1 exceed chronic water quality criterion, asterisk indicates acute criterion also exceeded in these samples.*

Sources of Metals Loading

Median turbidity, mercury, and copper values in Leach Creek decreased in a downstream gradient. The maximum mercury and copper concentrations observed were at the Holding Basin. The next site downstream at Emerson Street had mercury and, in most cases, copper levels slightly lower but still comparable to the Holding Basin. These results suggest the most important sources of metals are concentrated in the upstream part of the Leach Creek watershed.

Mercury and copper loads were calculated in an effort to better understand metals sources. The following formula was used:

discharge (cubic feet/second) x concentration (ug/L) x 2.45 = grams/day

The range of metals loading for all sites and sample events was 0.001-1.1 grams/day for mercury and 0.42- 701 for copper (Figures 13 and 14.).

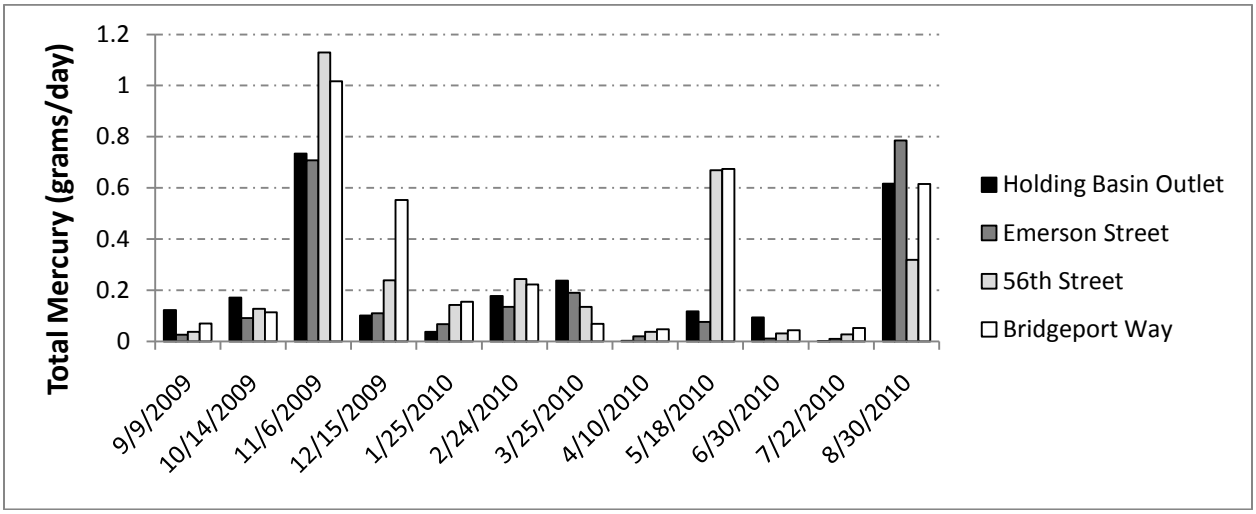

Figure 13. Total Mercury Loading in Leach Creek, 2009-10.

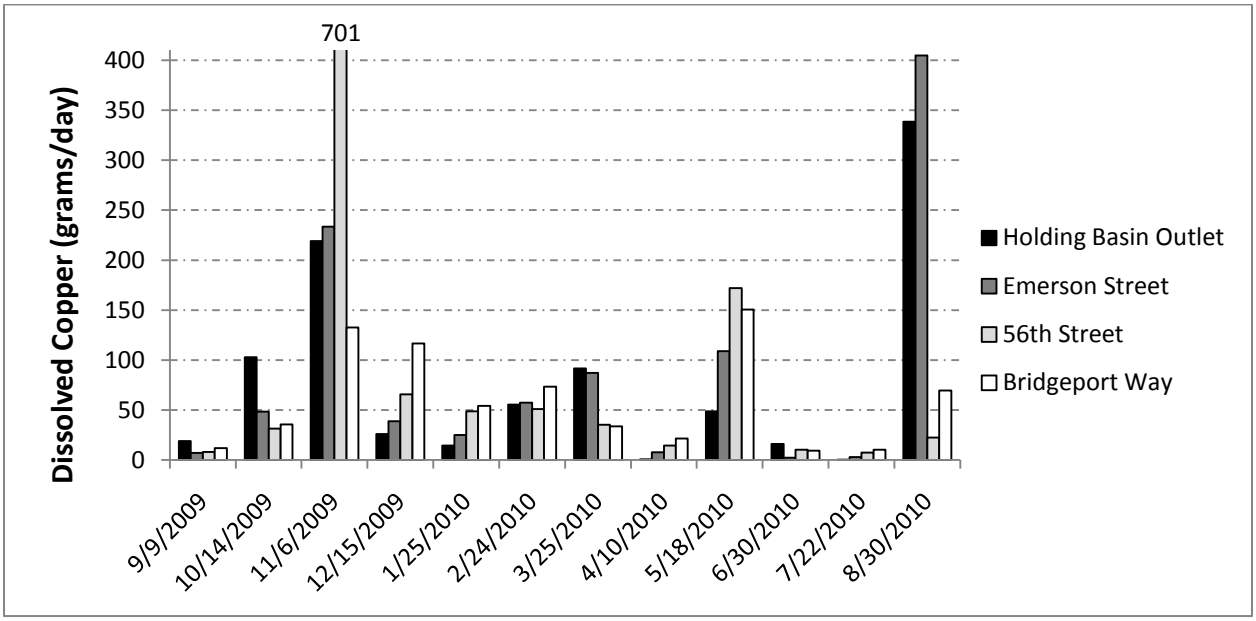

Figure 14. Dissolved Copper Loads in Leach Creek.

In contrast to metals concentrations, the loading data do not consistently point to the upstream parts of the Leach Creek watershed as being the most important sources of mercury or copper. This is predominantly due to the downstream samples having been collected at higher stream flows later during the runoff event. Also, several of the mercury loads for the 56th Street and Bridgeport Way sites are based on the detection limit (see Appendix A). The true load for these dates is unknown and would be lower than shown.

Mercury and Copper Levels in Other Western Washington Streams

Mercury and copper data from Ecology's ambient monitoring program were used to compare concentrations in Leach Creek to other Western Washington rivers and streams (data provided by Dave Hallock, FMU). Total mercury results were available for 91 stations. Dissolved copper results were available for 57 stations. These samples were collected from 1994 through 2010.

Approximately 15% (7 of 48) of the samples collected during this study exceeded the chronic criterion for mercury. In contrast, only 3% of ambient monitoring samples (15 of 453) exceeded the criterion. For the most part, the levels of mercury in Leach Creek during 2009-10 appear to be substantially higher than in other Western Washington rivers and streams (Figure 15).

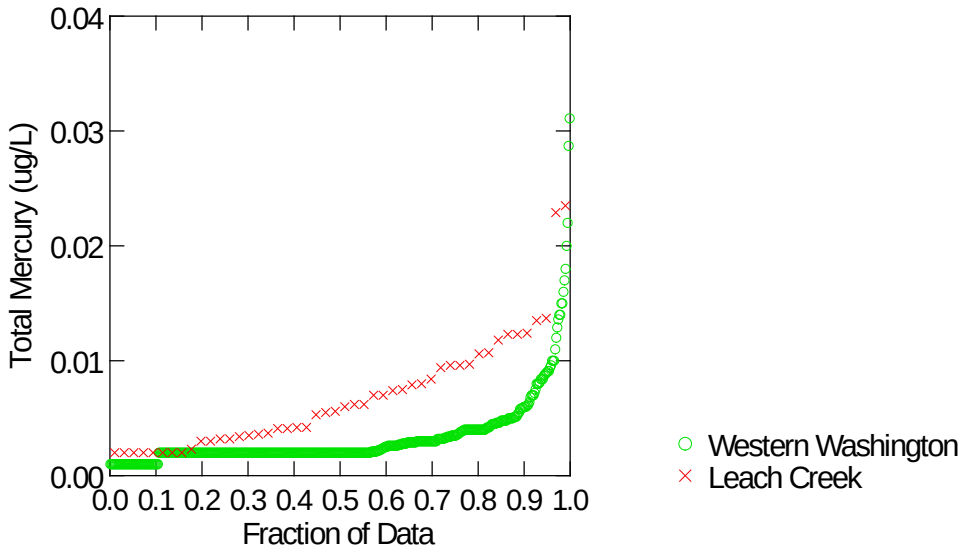

Figure 15. Mercury Concentrations in Leach Creek Compared to Other Western Washington Rivers and Streams.

One outlier (0.098 ug/L) deleted from Western Washington data; non-detects plotted at detection limit.

Higher copper concentrations also appear to be more characteristic of Leach Creek than other westside rivers and streams (Figure 16).

Comparability of these two data sets suffers in two respects:

1. Leach Creek is an urban stream previously identified as having a potential metals problem. Few, if any, of Ecology's ambient stations were selected for monitoring because of suspected metals contamination (Hallock, 2009).
2. The Leach Creek data are biased toward runoff events when metals concentrations are likely to be highest.

A comparison of the current study with results from other urban streams sampled predominantly during wet weather might give a different picture, although not detracting from the finding that Leach Creek is being adversely impacted by mercury and copper.

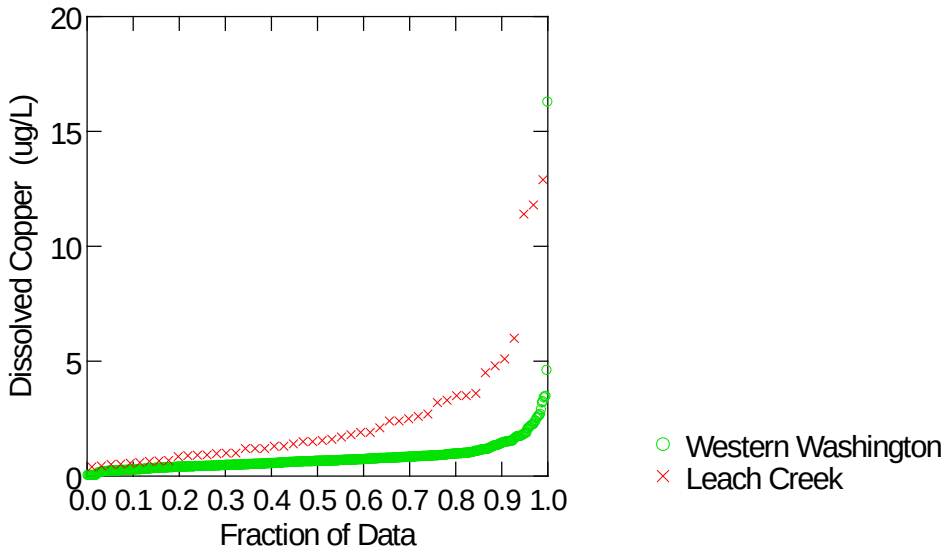

Figure 16. Copper Concentrations in Leach Creek Compared to Other Western Washington Rivers and Streams.

Non-detects plotted at reporting limit.

Conclusions and Recommendations

Conclusions

Objectives of this study were to better characterize mercury and copper levels in Leach Creek and determine if certain reaches have significant sources of these metals. Ecology conducted monthly monitoring from September 2009 through August 2010 at four locations from the Leach Creek Holding Basin to near the mouth of the creek at Bridgeport Way. An effort was made to collect samples during stormwater runoff events.

Significant findings were as follows:

- Mercury levels exceeded (did not meet) the chronic water quality criterion during four sampling events, seven samples in all. Some of the exceedances were marginal.
- Copper levels exceeded the chronic criterion during three sampling events, four samples in all. One sample also exceeded the acute criterion.
- Turbidity and higher streamflow were correlated with higher concentrations of mercury and copper. An extended dry-weather period followed by a stormwater runoff event resulted in the highest metal concentrations.
- The major sources of mercury and copper appear to reside in the upper reaches of Leach Creek.
- Mercury and copper levels in Leach Creek are elevated compared to many other Western Washington rivers and streams.

Recommendations

303(d) Listing

Leach Creek should be placed in Category 5 (303(d) list) of the Washington State Water Quality Assessment for exceeding aquatic life criteria for mercury and copper.

Source Investigation

If further efforts are made to identify metals sources to Leach Creek, the work should focus on the upstream reaches, especially those parts of the watershed with runoff to the Holding Basin. However, as noted elsewhere in this report, significant efforts by the City of Tacoma to identify and clean up metals sources in nearby watersheds have not met with much success.

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Appendices

Appendix A. Ecology's Monitoring Data for Mercury and Copper in Leach Creek, 2009-10.

Station	Sample No.	Date	Time	Flow (cfs)	Turbidity (NTU)	Total Mercury (ug/L)		Dissolved Copper (ug/L)		Hardness (mg/L)	Conduct. (umhos/cm)
Holding Basin Outlet	0909056-01	9-Sep-09	1045	6.7	2.1	0.0075		1.2		146	378
Emerson Street	0909056-02	9-Sep-09	1110	2.9	1.5	0.0036		1.0		153	387
56th Street	0909056-03	9-Sep-09	1128	3.7	1.5	0.0041		0.89		131	317
Bridgeport Way	0909056-04	9-Sep-09	1200	7.7	0.9	0.0037		0.64		116	282
Bridgeport replicate	0909056-05	9-Sep-09	1215	- -	1.0	0.0026		0.63		115	282
Filter blank	0909056-06	9-Sep-09	- -	- -	na	na		0.10	U	na	na
Bottle blank	0909056-07	9-Sep-09	- -	- -	na	0.002	U	na		na	na
Holding Basin Outlet	0910060-01	14-Oct-09	0850	12	17	0.0060		3.6		73	177
Emerson Street	0910060-02	14-Oct-09	0910	6.0	5.9	0.0062		3.3		76	181
56th Street	0910060-03	14-Oct-09	0935	9.8	4.8	0.0053		1.3		136	317
Bridgeport Way	0910060-04	14-Oct-09	1005	14	3.8	0.0032		1.0		128	298
Holding Basin Outlet	0911033-01	6-Nov-09	0735	25	7.9	0.0118		3.5		66	172
Emerson Street	0911033-02	6-Nov-09	0750	27	6.1	0.0107		3.5		61	154
56th Street	0911033-03	6-Nov-09	0810	48	9.0	0.0096		6.0		51	131
Bridgeport Way	0911033-04	6-Nov-09	0850	31	15	0.0135*		1.8		58	144
Holding Basin Outlet	0912024-01	15-Dec-09	0845	4.4	4.9	0.0094		2.4		97	263
Emerson Street	0912024-02	15-Dec-09	0902	6.4	3.7	0.0070		2.5		93	251
56th Street	0912024-04	15-Dec-09	0920	14	4.9	0.0070		1.9		56	153
Bridgeport Way	0912024-05	15-Dec-09	1000	31	6.2	0.0074		1.6		63	170
Holding Basin Outlet	1001067-01	25-Jan-10	0915	4.8	3.9	0.0032		1.2		129	352

Station	Sample No.	Date	Time	Flow (cfs)	Turbidity (NTU)	Total Mercury (ug/L)		Dissolved Copper (ug/L)		Hardness (mg/L)	Conduct. (umhos/cm)
East Channel to HB	1001067-08	25-Jan-10	0940	- -	16	0.0035		na		na	348
Emerson Street	1001067-04	25-Jan-10	1010	5.0	4.0	0.0055		2.1		102	261
Emerson replicate	1001067-07	25-Jan-10	1015	- -	4.3	0.0051		2.2		103	250
56th Street	1001067-05	25-Jan-10	1035	10	3.3	0.0056		1.9		72	171
Bridgeport Way	1001067-06	25-Jan-10	1125	15	3.0	0.0042		1.5		81	191
Filter blank	1001067-03	25-Jan-10	- -	- -	- -	na		0.10	U	na	- -
Bottle blank	1001067-02	25-Jan-10	- -	- -	- -	0.0020	U	na		na	- -
Holding Basin Outlet	1002069-01	24-Feb-10	0915	8.6	8.6	0.0084		2.6		54	147
Emerson Street	1002069-02	24-Feb-10	0935	8.9	7.5	0.0062		2.7		61	149
56th Street	1002069-03	24-Feb-10	0955	13	5.1	0.0079		1.7		89	164
Bridgeport Way	1002069-04	24-Feb-10	1025	22	4.0	0.0042		1.4		74	179
Holding Basin Outlet	1003070-01	25-Mar-10	1035	7.8	15	0.0124*		4.8*		35	94
Emerson Street	1003070-02	25-Mar-10	1050	8.0	13	0.0097		4.5		45	118
56th Street	1003070-03	25-Mar-10	1110	15.7	3.8	0.0035		0.92		136	309
Bridgeport Way	1003070-04	25-Mar-10	1140	14.1	2.3	0.0020	U	0.98		119	274
Holding Basin Outlet	1004034-01	29-Apr-10	1056	0.2***	2.2	0.0041		1.5		113	269
Emerson Street	1004034-02	29-Apr-10	1113	2.4	1.9	0.0034		1.3		123	293
56th Street	1004034-03	29-Apr-10	1120	5.1	1.8	0.0030		1.2		111	257
Bridgeport Way	1004034-04	29-Apr-10	1200	9.7	1.2	0.0020	U	0.91		103	247
Holding Basin Outlet	1005021-01	18-May-10	1815	3.9	10	0.0123*		5.1		58	142
Holding Basin replicate	1005021-02	18-May-10	1820	- -	9.3	0.0125		4.8		61	140
Emerson Street	1005021-05	18-May-10	1845	3.9	7.7	0.0080		11.4*	J	69	172
56th Street	1005021-06	18-May-10	1918	22.2	16	0.0123*		3.2		87	202

Station	Sample No.	Date	Time	Flow (cfs)	Turbidity (NTU)	Total Mercury (ug/L)		Dissolved Copper (ug/L)		Hardness (mg/L)	Conduct. (umhos/cm)
Bridgeport Way	1005021-07	18-May-10	2005	25.9	17	0.0106		2.4		97	223
Filter blank	1005021-03	18-May-10	1825	- -	na	na		0.10	U	na	na
Bottle blank	1005021-04	18-May-10	1825	- -	na	0.0020	U	na		na	na
Holding Basin Outlet	1006019-01	9-Jun-10	1038	4.5	4.2	0.0065		2.72		73	177
Holding Basin Outlet	1006067-01	30-Jun-10	1310	12.8	1.5	0.0030		0.52		155	363
Emerson Street	1006067-02	30-Jun-10	1340	1.9	1.8	0.0023		0.51		160	354
56th Street	1006067-03	30-Jun-10	1415	6.4	1.8	0.0020	U	0.66		151	328
Bridgeport Way	1006067-04	30-Jun-10	1500	8.8	1.1	0.0020	U	0.44		131	285
Holding Basin Outlet	1007017-01	22-Jul-10	1206	0.20	1.6	0.0020	U	0.85		156	341
Emerson Street	1007017-02	22-Jul-10	1224	2.0	2.1	0.0020	U	0.59		167	372
56th Street	1007017-03	22-Jul-10	1359	5.6	2	0.0020	U	0.56		155	342
Bridgeport Way	1007017-04	22-Jul-10	1430	10.7	1	0.0020	U	0.40		131	289
Holding Basin Outlet	1008015-01	31-Aug-10	1140	10.7	16	0.0235*		12.9**		37	104
Emerson Street	1008015-02	31-Aug-10	1155	14	17	0.0229*		11.8**		45	123
56th Street	1008015-03	31-Aug-10	1215	14	11	0.0096		0.68		146	346
Bridgeport Way	1008015-04	31-Aug-10	1250	18	18	0.0137*		1.55		128	296

na = not analyzed.
u = not detected at or above reported value.
J = qualified as an estimate.
* = chronic criterion exceeded.
** = acute criterion exceeded.
*** = verified low-flow value with Tacoma Public Works.

Appendix B. Glossary, Acronyms, and Abbreviations

Glossary

Ambient monitoring: Water quality sampling used to determine environmental conditions outside the influence of point sources of contamination.

Boxplot: A graphical depiction of a data set showing the 25th percentile, 50th percentile or median, the 75th percentile, range of data, and outliers.

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.

Conductivity: A measure of water's ability to conduct an electrical current. Conductivity is related to the concentration and charge of dissolved ions in water.

Exceed criteria: When concentrations of a contaminant are higher than (do not meet) the standards set forth by the State Surface Water Standards for toxics (WAC 173-201A-240).

First flush: A rain event following an extended dry period. Runoff from a first flush can contain elevated concentrations of contaminants.

Grab: A discrete sample from a single point in the water column or sediment surface.

Hardness: The concentration of minerals in water. For this project, hardness was determined by measuring the concentration of Calcium Carbonate.

Nonpoint: Unconfined and diffuse sources of contamination. Pollution that enters water from dispersed land-based or water-based activities. This includes, but is not limited to, atmospheric deposition, surface-water runoff from agricultural lands, urban areas, or forest lands, subsurface or underground sources, or discharges from boats or marine vessels not otherwise regulated under the National Pollutant Discharge Elimination System program.

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

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.

Point source: Sources of pollution that discharge at a specific location from pipes, outfalls, and conveyance channels to a surface water. Examples of point source discharges include municipal wastewater treatment plants, municipal stormwater systems, industrial waste treatment facilities, and construction sites that clear more than 5 acres of land.

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.

Reach: A specific portion or segment of a stream.

Salmonid: Any fish that belong to the family *Salmonidae*. Basically, any species of salmon, trout, or char. www.fws.gov/le/ImpExp/FactSheetSalmonids.htm

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 suspended solids (TSS): The suspended particulate matter in a water sample as retained by a filter.

Turbidity: A measure of water clarity. High levels of turbidity can have a negative impact on aquatic life.

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

CVAA	Cold Vapor Atomic Absorption
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
FMU	Freshwater Monitoring Unit
ICP/MS	Inductively Coupled Plasma/Mass Spectrometry
Manchester	Manchester Environmental Laboratory
RPD	Relative percent difference
SOP	Standard operating procedures
SM	Standard Methods
USGS	U.S. Geological Survey
WAC	Washington Administrative Code

Units of Measurement

cfs	cubic feet per second
mg/L	milligrams per liter (parts per million)
mL	milliliters
NTU	nephelometric turbidity units
ug/L	micrograms per liter (parts per billion)
umhos/cm	micromhos per centimeter