Monitoring Intertidal Seepage from the Port Angeles Landfill

DEPARTMENT OF ECOLOGY
State of Washington

April 2010
Publication No. 10-03-016

Publication and Contact Information

This report is available on the Department of Ecology's website at www.ecy.wa.gov/biblio/1003016.html.

Data for this project are available at Ecology's Environmental Information Management (EIM) website www.ecy.wa.gov/eim/index.htm. Search User Study ID, SGOL010.

Activity Tracker Code for this study is 10-130.

For more information contact:

Publications Coordinator
Environmental Assessment Program
P.O. Box 47600, Olympia, WA 98504-7600
Phone: (360) 407-6764

Washington State Department of Ecology - www.ecy.wa.gov/

- Headquarters, Olympia (360) 407-6000
- Northwest Regional Office, Bellevue (425) 649-7000
- Southwest Regional Office, Olympia (360) 407-6300
- Central Regional Office, Yakima (509) 575-2490
- Eastern Regional Office, Spokane (509) 329-3400

Cover photo:
Sampling a seep with a peristaltic pump just before inundation by a rising negative tide.

Monitoring Intertidal Seepage from the Port Angeles Landfill

by
Steven Golding

Toxics Studies Unit
Environmental Assessment Program
Washington State Department of Ecology
Olympia, Washington 98504-7710

Waterbody Number: WA-18-0010

This page is purposely left blank

Table of Contents

List of Figures and Tables

Page

Figures

Tables

.

Abstract

The Washington State Department of Ecology sampled two seeps on the beach in front of the Port Angeles landfill in August 2009. The sampling was initiated in response to a citizen's report of seeps discharging to the intertidal zone below the landfill at a minus tide.

The site was an unconfined disposal site until closed by the City of Port Angeles and capped in 1990. The portion of the landfill adjacent to the beach is unlined. A seawall to protect the toe of the landfill was completed in 2007.

Intertidal seep water was sampled for total recoverable and dissolved priority pollutant metals for comparison with water quality criteria. Samples were also analyzed for hardness, total suspended solids, and conductivity. At the time of sample collection, the seeps were estimated to flow at about eight gallons or less per minute.

Dissolved copper ranged from 20.3 to 27.0 µg/L and exceeded acute marine water quality criteria by a factor of approximately 6. Two of the four dissolved zinc samples exceeded the chronic marine water quality criterion. One of these was higher in concentration than the acute criterion.

Dissolved metals generally comprised more than half of the total metals. Finding a relatively small fraction of metals in particulate form is consistent with what would be expected from water leaching through a landfill.

Acknowledgements

The author of this report would like to thank the following people for their contribution to this study:

- Dan Brooks with Clallam County Streamkeepers for assistance with sampling.

Washington State Department of Ecology staff:

- Bill Harris for providing background information, and for reviewing the Quality Assurance Project Plan (QAPP) and final report.
- Dale Norton for reviewing the QAPP and final report.
- Art Johnson for reviewing the QAPP and final report.
- Paul Anderson for reviewing the final report.
- Tom Culhane for reviewing the final report.
- Carol Norsen for formatting and obtaining signature approvals for the QAPP.
- Joan LeTourneau, Cindy Cook, and Gayla Lord for formatting and editing the final report.

Introduction

The Port Angeles landfill is located within the city limits about four miles west of downtown Port Angeles. The landfill is on a bluff above a beach east of and adjacent to Dry Creek (Figure 1).

The area of landfill directly above the beach was closed by the City of Port Angeles, and capped in 1990. A retaining wall was completed in 2007 to stabilize the eroded bank of the unlined portion of the landfill adjacent to the beach and the Strait of Juan de Fuca.

Jim Jewell, a member of the community group, Dry Creek Coalition, sampled a seep on the beach in front of the seawall on June 3, 2008 during a minus series tide. The findings prompted follow-up sampling by the Washington State Department of Ecology (Ecology), results of which are reported here.

On August 18, 2009, Ecology sampled two seeps in front of the landfill wall exposed during a minus series tide. The samples were analyzed for a suite of 13 priority pollutant metals, magnesium, and ancillary parameters.

This report reviews findings from the August 18 field work and compares results with the City of Port Angeles data from leachate collected in a drain at the foot of the landfill on December 18, 2007 and July 31, 2008. Recent data from one of the city's groundwater monitoring wells behind the retaining wall are also included.

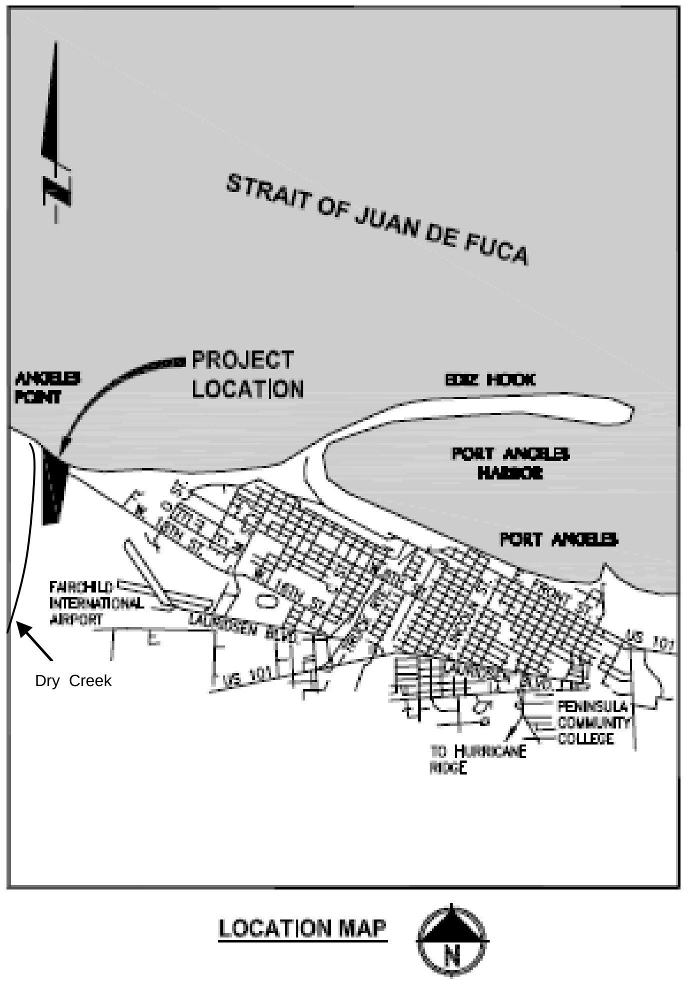

Figure 1. Study Site.

Figure from Aspect Engineering memorandum to City of Port Angeles Public Works and Utilities Department, 2009 – modified to show Dry Creek.

History of the Landfill

The Port Angeles landfill is located on a bluff above a beach adjacent to the Strait of Juan de Fuca. The landfill is within the Port Angeles city limits, about four miles west of downtown. A gravel pit there began being used as a dump in the early 1950s. Some ravines at the site were filled with solid waste. Wave action from the Strait of Juan de Fuca eroded the bank of the landfill so that debris, some as large as auto engines and transmissions, was deposited on the beach (Figure 2).

Figure 2. Bluff Erosion Prior to Construction of Seawall.

The City of Port Angeles Public Works Department took over operation of the landfill in 1979. Two to four inches of soil was placed over the landfill near the beach in 1983. An impermeable cap was installed in 1990 on the landfill area immediately south of the bluff to close the near-beach area of the landfill. Newer portions of the landfill are lined, but the portion near the beach (the original dump site) is not (Neal, 2009). The newer area of the landfill was closed in 2007.

A seawall, 454 feet long, was completed in October 2007 to stabilize the slope above the beach. The seawall foundation extends downward a minimum of 10 feet below mean higher-high water elevation (Neal, 2009). A perforated drain along the back side of the seawall collects leachate which is then discharged to the City of Port Angeles wastewater treatment plant. Three monitoring wells were placed at the toe of the slope behind the seawall as part of the slope stabilization project. One older monitoring well was installed in the beach at the toe of the natural bluff east of the seawall. A photograph of the wall appears as Figure 3.

Figure 3. Stabilized Slope and Seawall at Base of the Closed Landfill.

Photograph by Dry Creek Coalition.

Study Design

Field work for this study took place during a minus series tide when two beach seeps found in an earlier reconnaissance were exposed. Ecology collected samples of the seeps in the intertidal zone in front of the seawall on August 18, 2009, during a -1.7 feet tide. The samples were taken at 7:45 and 8:00 AM and when the seeps were close to inundation at 9:45 AM. The second seep was sampled a second time just before it was inundated by a rising tide. Clean sampling techniques were used to reduce the potential for contamination.

The principal Seep (Seep A) formed a small stream approximately two inches deep and five inches wide as it passed through narrow spaces between some debris in the beach sand. The second Seep (Seep B) was approximately 50 feet to the west of the first. It was approximately two inches deep and three to four inches wide. Seep B was sampled a second time since it was still flowing just as Seep A was inundated by a rising tide.

The seeps are in an area of beach with sufficient slope that the flow was well defined. Both seeps are located at about mid-span of the seawall, approximately 100 feet seaward of the wall. They can be visually located directly opposite a monitoring well (MW-11) with an orange cap.

The seep samples were analyzed for 13 priority pollutant metals as well as magnesium, sodium, chloride, sulfate, hardness, conductivity, and total suspended solids. Analytical methods were chosen to give reporting limits low enough to compare to water quality criteria and results from previous seawall drain water (Aspect Engineering, 2009). Conductivity was measured with a portable conductivity meter.

Field Methods

Water samples were collected using a peristaltic pump fitted with Teflon intake tubing. The opening of the intake tubing was held just below the water surface so as not to disturb the underlying sediment. Seep water was pumped through the system for one minute to rinse the collection line before each sample was collected.

Before sampling, new silastic tubing was installed in the pump housing. The pump and tubing assembly were pre-cleaned by pumping a solution of Liquinox® detergent, followed by sequential rinses with deionized water, laboratory grade 10% nitric acid, and deionized water.

Procedures for collection of metal samples followed guidance in EPA Method 1669, *Sampling Ambient Water for Trace Metals at EPA Water Quality Levels* (EPA, 1995). Samples for dissolved metals were filtered in the field through pre-cleaned 0.45 µm Nalgene filter units (#450-00045, type S), preserved with HNO_3 (nitric acid) in Teflon vials, and collected in high density polyethylene (HDPE) bottles supplied by Ecology's Manchester Environmental Laboratory (MEL). Sampling personnel wore powder-free nitrile gloves.

Conductivity was measured with a portable meter following Ecology's Standard Operating Procedure (SOP) EAP032 (Ward, 2007). For the principal (eastward) seep, a handheld GPS unit was used following SOP EAP013 (Janisch, 2006). Coordinates were (NAD 83) latitude 48.13375 and longitude -123.51902.

A summary of parameters, collection containers, preservation, and holding times by parameter is shown in Table 1. Reporting limits appear in Table 2.

Table 1. Sample Size, Container, Preservation, and Holding Time by Parameter

Parameter	Sample Size	Container	Preservation	Holding Time
PP metals (TR and diss)*	500 mL	1 L HDPE bottle	(field filtered dissolved) HNO_3 to pH < 2 Cool to 4ºC	6 months
Total suspended solids	1000 mL	1000 mL wide-mouth poly	Cool to 4ºC	7 days
Hardness	100 mL	100 mL	H_2SO_4 to pH<2	6 months
Sodium	500 mL	500 mL wide-mouth poly	Cool to 4ºC	28 days
Chloride				
Sulfate				

*Mercury analyzed as total recoverable form only.
PP – Priority pollutant.
TR – Total recoverable.

Analytical Methods

MEL analyzed all project samples. Metals samples, with the exception of mercury, were analyzed by Inductively Coupled Plasma Mass Spectroscopy (ICP/MS) using EPA Method 200.8. Mercury was analyzed by cold vapor atomic absorbance (CVAA) using Methods 245.1 and 245.5.

Analytical methods and reporting limits are shown in Table 2.

Table 2. Analytical Methods.

Parameter	Analysis	Reporting Limit	Sample Preparation	Analytical Method
PP Metals	Total recoverable	0.1 – 0.5 µg/L*	HNO_3/HCL digest	EPA 200.8
	Dissolved	0.1 – 0.5 µg/L*	HNO_3/HCL digest, filtered and preserved	EPA 200.8
Mercury	Total recoverable	0.05 µg/L	HNO_3/HCL digest	Cold Vapor Atomic Absorbance Methods 245.1 And 245.5
Magnesium	Total recoverable	0.05 mg/L	HNO_3/HCL digest	EPA 200.8
	Dissolved	0.1 mg/L	HNO_3/HCL digest, filtered and preserved	EPA 200.8
TSS	Whole water	1 mg/L	NA	EPA 160.2

*5 µg/L and 1 µg/L for total recoverable and dissolved zinc, respectively.

PP = Priority pollutant.
NA = Not applicable.
HNO^3 = Nitric acid.
HCl = Hydrochloric acid.

Reporting limits were low enough to compare to Washington State marine water criteria (Table 3) with the exception of mercury with a reporting limit of 0.05 µg/L and a marine chronic water quality criterion of 0.012 µg/L.

Data Quality

This study was conducted following a Quality Assurance Project Plan (Golding, 2009). Appendix A has measurement quality objectives (MQOs) for the project. Quality assurance data are shown in Appendix B.

Manchester Laboratory prepared written quality assurance reviews on the quality of the metals data for this project. The reviews included 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.

MQOs for laboratory check standards/control standards, duplicates, matrix spikes, matrix spike duplicates, and reporting limits were met with the following exceptions:

- Several samples were analyzed at a dilution due to matrix interference. The reporting limits for these samples were raised accordingly and are shown in Figure 3.
- One of the continuing calibration checks failed for dissolved chromium, dissolved arsenic, and dissolved selenium. The results for these metals were qualified as estimates.
- The matrix spike recoveries for total sodium and total magnesium failed. The standard spiking level was insufficient for the elevated concentration of analyte in the source sample but no action on the part of the laboratory was considered necessary.
- The recoveries for total selenium failed. The source sample result was qualified as an estimate.

The laboratory did not encounter any other problems in the analyses of these samples. All other sample results were reported without qualification.

The laboratory received the samples within the proper range of 0 - 4°C. All analyses were performed within holding times. No analytically significant levels of analyte were detected in the method blanks associated with these samples. All relative percent differences (RPDs) for laboratory duplicates with concentrations greater than 5 times the reporting limit were within the acceptance range of 0% - 25%. All laboratory control recoveries were within acceptable limits. All internal standard recoveries were within acceptance limits.

Field filter blanks were analyzed to detect contamination arising from the filtration process. All field filter blanks were nondetected or below 0.50 µg/L, with the exception of dissolved zinc at 16.0 µg/L (Table B-1). Silastic tubing in the pump that cannot be fully priority-pollutant cleaned may be the source of the zinc contamination. The "5 times rule" requires a valid result to be at least 5 times higher than a nondetected reported result. The 50.7 µg/L result for dissolved zinc at Seep B (Table 3) is only 3 times the 16.0 µg/L blank concentration. For this reason, zinc results less than 5 times the blank concentration have been qualified with J (Momohara, 2010).

Selected samples were collected in replicate to provide estimates of the variability (field plus laboratory) associated with the data reported here. All replicates had RPDs of less than 5%, with the exception of lead with a RPD of 27%.

Results

Ecology's results from analyzing metals and ancillary water quality parameters in intertidal seepage from the Port Angeles landfill are shown in Table 3.

Table 3. Results of Seep Sampling and Comparisons with Washington State Water Quality Criteria.

Parameter		Seep A		Seep B		Seep B		Marine Water Quality Criteria (µg/L)	
		Total Recoverable	Dissolved	Total Recoverable	Dissolved	Dissolved	Replicate Dissolved	Acute	Chronic
	Date:	8/18/09	8/18/09	8/18/09	8/18/09	8/18/09	8/18/09		
	Time:	0745	0745	0800	0800	0945	0945		
Metals									
Arsenic	(µg/L)	7.22 J	4.86 J	6.1 J	2.88	14.2 J	13.6 J	69	36
Silver	(µg/L)	1.00 U	0.200 U	1.00 U	0.200 U	0.200 U	0.200 U	1.9	--
Antimony	(µg/L)	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	--	--
Beryllium	(µg/L)	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	--	--
Cadmium	(µg/L)	1.00 U	0.200 U	1.00 U	0.200 U	0.200 U	0.200 U	42.0	9.30
Chromium (trivalent)	(µg/L)	34.6 J	5.00 U	31.70 J	5.00 U	63.8 J	66.1 J	--	--
Copper	(µg/L)	24.9	23.7	22.4	20.3	27.0	26.2	4.80	3.10
Mercury	(µg/L)	0.050 U		0.050 U				1.80	0.025
Lead	(µg/L)	2.61	2.24	1.83	1.33	0.438	0.333	210	8.10
Magnesium	(mg/L)	362	305	304	295	511	508	--	--
Nickel	(µg/L)	4.87	3.74	4.30	3.20	6.69	6.85	74.0	8.20
Selenium	(µg/L)	44.8 J	27.9 J	21.6	14.7	54.8 J	52.4 J	290	71.0
Thallium	(µg/L)	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	--	--
Zinc	(µg/L)	77.7 J	62.8 J	64.3 J	50.7 J	90.1	88.1	90.0	81.0
Conventionals									
Sodium	(mg/L)	2480		2170					
Chloride	(mg/L)	3960		3840					
Sulfate	(mg/L)	559		530					
TSS	(mg/L)	6		2					
Hardness	(mg/L)	1530		1520					
Conductivity	(mS/cm)	10.8		10.2		11.8			

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

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

Exceeds chronic and acute water quality criteria.

Both principal Seep A and Seep B were sampled at low tide. In addition, the second Seep B sample was collected just as Seep A was inundated by the rising tide.

Metals concentrations from the two seeps at low tide were similar. The mean RPD for detected dissolved metals from Seep A and the first sample from Seep B was 31%.

For most metals in the Seep B sample, concentrations tended to be highest in the second sample at 9:45 a.m. Arsenic, chromium, magnesium, nickel, selenium, and zinc concentrations of both dissolved and total metals increased by factors of about 1.5 to 2. Dissolved lead decreased between 8:00 and 9:45 a.m. samples by a factor of about 5. Silver, antimony, beryllium, cadmium, and thallium were not detected in any of the samples.

Comparisons to Washington State Water Quality Standards

State marine water quality standards (WAC 173-201A) are shown in Table 3. The standards are based on the dissolved form of metals with the exception of mercury. Copper and zinc in the seep water exceeded marine water quality criteria. Copper in both seeps exceeded criteria. Copper concentrations were in the range of 20 -27 µg/L, exceeding acute and chronic water quality criteria by factors of about 5 and 7, respectively. Zinc in the second Seep B sample exceeded the chronic criterion by 10%, and the concentration was at the acute criterion.

The standard Manchester Laboratory tests for chromium are for the trivalent, not hexavalent, form. There are no water quality standards for trivalent chromium. Marine water quality standards apply to the hexavalent form only.

Hardness analyses showed highly elevated concentrations (above 1,500 mg/L) compared with typical freshwater hardness values of a few hundred mg/L at most. Hardness data were collected as an ancillary parameter for potential comparisons with freshwater quality criteria. These will not be considered in this report. Marine water quality criteria are not hardness dependent.

Flow

A rough estimate of the flow from Seep A was made by measuring the channel dimensions and estimating velocity. The channel was 5 inches wide and 2 inches deep, and floating debris was observed to travel at approximately 0.25 ft/s. This corresponds to approximately 8 gallons per minute. Flow appeared to be lower in the second seep but not measured.

Dissolved Fraction of Metals

A comparison of total to dissolved metals is shown in Table 4. Metals were mostly in dissolved form with a considerable range between metals. Copper was found at 91 -95 % dissolved to total concentration, the highest dissolved fraction of all metals.

Table 4. Fraction of Metals Sampled August 18, in Dissolved Form.

Metal		Seep A	Seep B
	Time:	0745	0745
Arsenic	(µg/L)	67% (est.)	47%
Silver	(µg/L)	U	U
Antimony	(µg/L)	U	U
Beryllium	(µg/L)	U	U
Cadmium	(µg/L)	U	U
Chromium	(µg/L)	U	U
Copper	(µg/L)	95%	91%
Lead	(µg/L)	86%	73%
Magnesium	(mg/L)	84%	97%
Nickel	(µg/L)	77%	74%
Selenium	(µg/L)	62% (est.)	68%
Thallium	(µg/L)	U	U
Zinc	(µg/L)	81%	79%

U – The analyte was not detected.

Proportions of Ions in Seep Water

The concentration of ions in the seep samples with seawater ions allows percent freshwater in the seeps to be estimated. Although the total amount of salinity may vary between samples, the ratio of major salts in samples of seawater from many locations is constant (Forchhammer's Principle). This principle is applied in Table 5. All ions concentrations were found between 20.0 and 20.9% of seawater concentrations with the exception of Seep A with a sodium concentration of 23.5% of seawater.

Table 5. Seep Ion Concentrations (mg/L) as Percentage of Seawater Ion Concentrations.

Ion	Seawater ion concentrations*	Seep ion concentrations	Sampled ion concentrations as % seawater
Seep A			
Sodium	10,560	2,480	23.5%
Chloride	18,980	3,960	20.9%
Sulfate	2,649	530	20.0%
Seep B			
Sodium	10,560	2,170	20.6%
Chloride	18,980	3,840	20.2%
Sulfate	2,649	530	20.0%

* From www.lenntech.com/composition-seawater.htm.

Measured conductivities (10.2 – 11.8 mS/cm) were about 21– 25% of the conductivity of seawater (48 mS/cm). These data led to the conclusion that there was about 1 part freshwater to 4 parts seawater in the seep samples.

Related Data from Other Studies

Monitoring Well Data

The City of Port Angeles sampled monitoring well MW-11 behind the seawall for metals on August 25, 2009. William Harris of Ecology obtained split samples from the City for analyses by Manchester Laboratory (Harris, 2009). The City's results have not yet been received, but the analysis was by a different method which led to higher detection limits.

Table 6 shows Ecology results for the MW-11 split from MW-11.

Table 6. Monitoring Well (MW-11) Data (µg/L), August 25, 2009.

Metal	Total Recoverable Metals		Dissolved Metals		Dissolved Fraction
Arsenic	0.84		0.28		33%
Silver	0.10	U	0.020	U	
Antimony	0.21		0.20	U	
Beryllium	0.10	U	0.10	U	
Cadmium	0.10	U	0.020	U	
Chromium	4.38		2.22		51%
Copper	5.11		0.47		9%
Mercury	0.050	U	0.050	U	
Lead	0.85		0.210		25%
Nickel	7.93		0.51		6%
Selenium	0.50	U	0.50	U	
Thallium	0.10	U	0.10	U	
Zinc	34.4		1.0	U	

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

Seawall Drain Data

Aspect Consulting monitored leachate for total recoverable metals from a drain along the back side of the seawall for the City of Port Angeles on December 18, 2007 and July 31, 2008 (Table 7).

Table 7. City of Port Angeles Total Recoverable Metals in Seawall Drain Leachate (µg/L).

Metal	Date Sampled	
	12/18/07	7/31/08
Arsenic	2	50 U
Silver	8	4
Antimony	100 U	50 U
Beryllium	2 U	2
Cadmium	4 U	5
Chromium	10 U	199
Copper	9	554
Mercury	0.10 U	0.7
Lead	5 U	350
Nickel	7	220
Selenium	3	50 U
Thallium	100 U	50 U
Zinc	20	1230

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

Metals concentrations from the July 2008 sample were much higher than in December 2007, typically by a factor of about 50. The increase in metals levels was attributed to the sample being collected with a bailer that likely caused a disturbance of sediments. Less dilution of sea wall fluids during the dry season is also a possible factor (Aspect, 2009).

Comparison of Study Data

Results from all three studies are shown in Table 8. Only those metals detected in at least one of the studies are shown.

Table 8. Comparison of Metals from Seep Results with Results from Two Other Studies (µg/L).

Metal	Seeps				Monitoring Wells				Seawall Drain			
	8/18/09 (0745)				8/25/09				12/18/2007		7/31/2008	
	Total		Dissolved		Total		Dissolved		Total			
Arsenic (µg/L)	7.22	J	4.86	J	0.84		0.28		2		50	U
Silver (µg/L)	1.0	U	0.20	U	0.10	U	0.02	U	8		4	
Antimony (µg/L)	2.0	U	2.0	U	0.21		0.20	U	100	U	50	U
Beryllium (µg/L)	1.0	U	1.0	U	0.10	U	0.10	U	2	U	2	
Cadmium (µg/L)	1.0	U	0.20	U	0.10	U	0.02	U	4	U	5	
Chromium (tri) (µg/L)	34.6	J	5.0	U	4.38		2.22		10	U	199	
Copper (µg/L)	24.9		23.7		5.11		0.47		9		554	
Mercury (µg/L)	0.05	U	--		0.05	U	0.05	U	0.10	U	0.7	
Lead (µg/L)	2.61		2.24		0.85		0.21		5	U	350	
Magnesium (mg/L)	362		305		--		--		--		--	
Nickel (µg/L)	4.87		3.74		7.93		0.51		7		220	
Selenium (µg/L)	44.8	J	27.9	J	0.50	U	0.50	U	3		50	U
Thallium(µg/L)	1.0	U	1.0	U	0.10	U	0.10	U	100	U	50	U
Zinc (µg/L)	77.7	J	62.8	J	34.4		1.0 U		20		1230	

U – The analyte was not detected at or above the reported result.
J – The analyte was positively identified. The associated numerical result is an estimate.

Concentrations of all metals found in the seeps, except silver and nickel, were higher than results from the City of Port Angeles monitoring well and the December 2007 seawall drain studies. Nickel concentrations were similar in all three studies.

Both of the metals from the seep samples that exceeded water quality criteria (copper and zinc) were also found in samples from the other two studies. Copper and zinc concentrations were more than double the concentrations in the seep samples than from the other two studies.

Conclusions and Recommendations

Conclusions

Seep water samples from this August 2009 study showed elevated concentrations of some metals. Results showed dissolved zinc and copper above Washington State marine water quality criteria, with copper (ranging from 20.3 – 27.0 µg/L) at about six times the criteria. The seep water was found to have approximately 21% of the ionic strength of seawater, indicating a ratio of freshwater to marine water of approximately 1:4.

The seeps, with their small flow rate of eight gallons per minute or less, have a negligible impact on water quality in the Strait of Juan de Fuca. The presence and extent of a more generalized impact through the groundwater/surface water interface cannot be ruled out. The groundwater gradient seaward from the landfill is not known. The extent of any leachate seeping through the beach is also unknown.

Based on data from the monitoring well and seawall drain, it is clear that the seeps on the beach are influenced by groundwater and/or leachate from the landfill. All metals found in the seep samples, with the exception of selenium, were also found in the monitoring well samples. Selenium was found in the seawall drain samples.

Recommendations

Although leachate from the seawall drain is pumped to the Port Angeles wastewater treatment plant, the finding of seep water contamination on the beach in front of the seawall supports the need for continued sampling of the monitoring well and seawall drain. The resultant data will provide an indication of leachate strength and mobility so that further seep water monitoring may not be necessary.

Consistent methods for sampling of the seawall drain should be used to reliably represent leachate strength so that overall and seasonal metals concentrations can be determined.

References

Aspect Engineering, 2009. Memorandum to Terri Partch, P.E., City of Port Angeles, Public Works and Utilities Department, Port Angeles, WA.

EPA, 1995. Method 1669 Sampling Ambient Water for Trace Metals at EPA Water Quality Levels. U.S. Environmental Protection Agency. 40 CFR Parts 136 and 503.

Golding, Steven, 2009. Quality Assurance Project Plan: Monitoring Seep Water from the Port Angeles Landfill to an Intertidal Area. Publication 09-03-125. September 2009. www.ecy.wa.gov/biblio/0903125.html.

Harris, William, 2009. State of Washington Department of Ecology, Email to Jennifer Garcelon, Clallam County. MW-11 Priority Pollutant Metals Analyses – 08/25/09 Sampling. October 8, 2009.

Janisch, Jack, 2006. Standard Operating Procedures for Determining Global Positioning System Coordinates. Environmental Assessment Program. Washington State Department of Ecology, Olympia, WA. www.ecy.wa.gov/programs/ea[/quality.html.

Lenntech Water Treatment and Air Purification, 2010. Major ion composition of seawater. Delft, The Netherlands. www.lenntech.com/composition-seawater.htm.

Momohara, Dean, 2010. Personal communication. Washington State Department of Ecology, Manchester Environmental Laboratory, Manchester, WA.

Neal, Kathryn, 2009. Personal communication. Engineer Manager, City of Port Angeles. July 30, 2009.

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

Ward, William, 2007. Standard Operating Procedures (SOP) for the Collection and Analysis of Conductivity Samples, Version 1.3. Washington State Department of Ecology, Olympia, WA. SOP Number EAP032. www.ecy.wa.gov/programs/ea[/quality.html.

Appendices

Appendix A. Quality Assurance Requirements

Table A-1. Measurement Quality Objectives for Analysis of Water Samples

Analysis	Check Standards/LCS (recovery)	Duplicates (RPD)	Matrix Spikes (recovery)	Matrix Spikes Duplicates (RPD)
Priority Pollutant Metals	85-115%	25%	75-125%	20%
Total Suspended Solids	80-120%	25%	NA	NA
Conductivity	--	25%	NA	NA

LCS – Laboratory control sample.
RPD – Relative percent difference.
NA – Not applicable.

Appendix B. Quality Assurance Data

Table B-1. Filter Blanks for Dissolved Metals (µg/L), August 18, 2009.

Arsenic (µg/L)	0.10	J
Silver (µg/L)	0.02	U
Antimony (µg/L)	0.20	U
Beryllium (µg/L)	0.10	U
Cadmium (µg/L)	0.02	U
Chromium (µg/L)	0.25	J
Copper (µg/L)	0.21	
Lead (µg/L)	0.02	U
Magnesium (mg/L)	0.05	
Nickel (µg/L)	0.10	U
Selenium (µg/L)	0.50	J
Thallium (µg/L)	0.10	U
Zinc (µg/L)	16.00	

U – The analyte was not detected at or above the reported result.
J – The analyte was positively identified. The associated numerical result is an estimate.

Table B-2. Field Replicates for Dissolved Metals (µg/L), August 18, 2009 (time: 0945).

Metal	Seep B		Seep B Replicate		Relative Percent Difference (RPD)	
Arsenic (µg/L)	14.2	J	13.6	J	4.3%	(est.)
Silver (µg/L)	0.200	U	0.200	U		
Antimony (µg/L)	2.00	U	2.00	U		
Beryllium (µg/L)	1.00	U	1.00	U		
Cadmium (µg/L)	0.200	U	0.200	U		
Chromium (µg/L)	63.8	J	66.1	J	3.5%	(est.)
Copper (µg/L)	27		26.2		3.0%	
Mercury (µg/L)						
Lead (µg/L)	0.438		0.333		27%	
Magnesium (mg/L)	511		508		0.60%	
Nickel (µg/L)	6.69		6.85		2.4%	
Selenium (µg/L)	54.8	J	52.4	J	4.50%	(est.)
Thallium (µg/L)	1.00	U	1.00	U		
Zinc (µg/L)	90.1		88.1		2.00%	

U – The analyte was not detected at or above the reported result.
J – The analyte was positively identified. The associated numerical result is an estimate.

Appendix C. Glossary, Acronyms, and Abbreviations

Glossary

Analyte: Water quality constituent being measured (parameter).

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.

Dissolved metals: Metals entrained in water, defined as passing through a 0.45 µm filter.

Exceeded criteria: Failed to meet criteria.

Intertidal zone: The area of the beach between the high and the low tide waterlines.

Leachate: The liquid that drains or "leaches" from a landfill.

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

Priority pollutant metals: A standards suite of 13 metals: arsenic, aluminum, antimony, beryllium, cadmium, chromium, copper, mercury, lead, nickel, selenium, thallium, and zinc**.**

Seep: A place where small flows of water exit the ground or other solid surface.

Total recoverable metals: Total metals analyzed following an acid extraction process.

Total suspended solids: Portion of solids retained by a 0.45 µm filter.

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

Acronyms and Abbreviations

Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
GPS	Global Positioning System
MEL	Manchester Environmental Laboratory
NAD	North American Datum
RPD	Relative percent difference
SOP	Standard operating procedure
USGS	U.S. Geological Survey
WAC	Washington Administrative Code

Units of Measurement

g	gram, a unit of mass
mg/L	milligrams per liter (parts per million)
mS/cm	millisiemens per centimeter
µg/L	micrograms per liter (parts per billion)
µmhos/cm	micromhos per centimeter