WASHINGTON STATE
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Investigation of Chemical Contamination at Whitmarsh Landfill and Padilla Bay Lagoon

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by
Art Johnson

Washington State Department of Ecology
Environmental Assessment Program
Watershed Ecology Section
PO Box 47600
Olympia, WA 98504-7600

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Abstract

Intertidal seepage and sediment samples collected at Whitmarsh Landfill on Padilla Bay Lagoon were analyzed to identify chemical contaminants of potential concern to marine life and human health. A sediment quality survey was subsequently conducted in the lagoon. Results are compared to historical data and evaluated in terms of elevations over reference areas, compliance with state Sediment Management Standards, and sources of contamination.

The lagoon is recommended for inclusion on Ecology's Contaminated Sediments Site List, based on sediment station clusters of potential concern for 2-methylphenol, 4-methylphenol, 2,4-dimethylphenol, and the echinoderm bioassay. The area should be evaluated as a priority for cleanup activities.

Summary

In response to concerns of the Swinomish Tribal Community, the Washington State Department of Ecology conducted an investigation to determine the extent to which Padilla Bay Lagoon has been degraded by discharges from the Whitmarsh Landfill. The abandoned fill is located at the head of Padilla Bay on tidelands at the west end of the lagoon. It was used as an unregulated public dump from the 1950s until 1973. Previous investigations had concluded the level of chemical contamination in the lagoon was low and not readily traceable to the fill. Results of toxicity tests on the sediments seemed to contradict these findings.

An extensive chemical screening was first conducted on two samples each of seepage and intertidal sediments collected at the base of the landfill on June 11, 1998. The analyses included a wider range of compounds and lower detection limits than had been done previously.

The contaminants detected in Whitmarsh seepage and their concentration ranges (parts per billion) are listed below. A number of additional benzenes, phenols, and polyaromatic hydrocarbons (PAH) were also tentatively identified.

Chemical Contaminant (number of compounds)	Whitmarsh Seepage (ug/L)
iron	5,600 - 16,600
diesel	470 - 850
benzenes (5)	0.1 - 2.5
chlorinated benzenes (4)	0.01 - 0.92
xylenes (3)	0.14 - 1.3
toluene	0.15 - 0.86
ethylether	0.51
polyaromatic hydrocarbons (14)	0.02 - 0.84
phenol and methylphenols (4)	0.08 - 0.52
chloromethylphenol	0.52
diethylphthalate	0.14 - 0.19
nitrosodiphenylamine	0.41 - 1.5
dibenzofuran	0.08 - 0.16
carbazole	0.05
PCB-1242	0.011 - 0.028
carbaryl	0.012 - 5.8

The concentrations in seepage were generally low and, in most cases, beneath thresholds of toxicity. Iron and the higher concentrations of the insecticide carbaryl (Sevin) were potentially toxic until further diluted. PCB-1242 approached the chronic water quality criterion of 0.03 ug/L for marine waters.

Chemicals analyzed but not detected in the seepage were priority pollutants metals, cyanide, organophosphorus pesticides, organochlorine pesticides, and herbicides. Previous investigations by Skagit County and others have also shown that metals, cyanide, and pesticides are not important contaminants in the seepage.

Results from screening the Whitmarsh sediment samples showed elevations in a range of chemicals including, but not limited to, iron, PAH, phenols, phthalates, and 2,3,7,8-TCDD (dioxin). Methylphenols exceeded Ecology's Sediment Management Standards (SMS). Chemicals analyzed but not detected in the sediments were PCBs, organophosphorus pesticides, organochlorine pesticides, and herbicides. Organotins were at background levels.

The screening results were consistent with past studies indicating there was a low potential for the landfill to cause toxicity in the lagoon water column. Sediment contamination, however, appeared to be a greater concern than had previously been appreciated. A wider sediment quality survey was therefore conducted in the lagoon.

The objectives of the sediment survey were to:

- Determine the occurrence of chemicals of potential concern
- Determine the extent of contamination
- Assess compliance with SMS chemical and biological criteria
- Evaluate the significance of contamination by non-SMS chemicals
- Draw conclusions about probable sources of contamination

Samples for the expanded sediment survey were collected August 7, 1998 and included three sites farther out in the lagoon (#3, #4, and #5), one site outside the lagoon (#6), and an established reference area nine miles to the north in Samish Bay. Sediments in the reference area are known to have a low level of chemical contamination and no significant toxicity. The samples were analyzed for a subset of the screening survey chemicals and tested for acute toxicity to amphipod crustaceans (*Ampelisca abdita*), sea urchins (*Stongylocentrotus purpuratus*), and chronic toxicity to juvenile polychaete worms (*Neanthes arenaceodentata*).

The major findings from Ecology's 1998 investigation on sediment quality in Padilla Bay Lagoon can be summarized as follows:

2-Methylphenol, 4-methylphenol, and 2,4-dimethylphenol in the inner lagoon exceed SMS Cleanup Screening Levels (CSL). A station cluster of potential concern (sites #1, #2, and #3) exists for these compounds, making it a priority for evaluation as a cleanup site.

Site	2-Methylphenol	4-Methylphenol	2,4-Dimethylphenol
#1	180	545	288
#2	121	238	118
#3	1740	7950	5580
CSL =	63	670	29

ug/Kg, dry; parts per billion

Except for phenol at inner lagoon site #3, all other SMS chemicals were within Sediment Quality Standards (SQS). Chemicals meeting the SQS are not expected to cause adverse effects on biological resources.

Chemicals, in addition to phenols, that are substantially elevated in the lagoon and appear to be associated with Whitmarsh Landfill include iron, low molecular weight PAH, high molecular weight PAH, bis(2-ethylhexyl)phthalate, di-n-butylphthalate, coprostanol (an indicator of fecal matter), dibenzofuran, retene, and 2,3,7,8-TCDD. Sources other than Whitmarsh Landfill are indicated for higher weight PAH in the outer lagoon and outside the lagoon.

In terms of equivalent concentrations of 2,3,7,8-TCDD, the levels of polychlorinated dioxin and -furan compounds in the lagoon (up to 5.7 ng/Kg; parts per trillion) are comparable to some industrialized embayments in Puget Sound. EPA has concluded that this level of sediment contamination poses a low risk to fish and wildlife.

Among the chemicals analyzed in the sediments, but either not detected or not substantially elevated, were total petroleum hydrocarbons (except site #3), priority pollutant metals, volatile organic compounds (except #3), and PCBs.

Site #3 is located on the north side of the inner lagoon, approximately 200 yards east of the landfill. It has extremely high levels of petroleum (5,300 mg/Kg diesel; 4,000 mg/Kg lube oil; parts per million) and, as noted above, phenols. The sediments are black, viscous, and have a strong petroleum odor. The hydrocarbons were extremely weathered and do not match any pattern of common petroleum products. All bioassay test organisms died on exposure to this sample. Given its distance from the landfill, the source of this material may be a spill from the adjacent railroad tracks. Alternately, it could be that historical discharge of a dense product from the landfill followed the lagoon drainage channel that passes through this site.

The percentage of abnormal larvae in the sea urchin bioassay exceeded CSLs both inside and outside the lagoon. A station cluster of potential concern (sites #3, #4, #5, and #6) exists for this bioassay, making it a priority for cleanup evaluation. The chemical data furnish no clues to the reason for the toxicity seen at sites #4, #5, and #6.

Site	Amphipod % Survival	Sea Urchin % Normal	Polychaete % Survival	Polychaete Biomass (g)
Lab Control	90	82	100	11.3
Reference Area	95	77	100	10.9
#6	91	32*	100	9.3*
#5	95	35*	88	9.6*
#4	83	36*	96	11.5
#3	0*	0*	0*	- -

*significantly less ($p < .05$) than reference sediments

The amphipod and polychaete bioassays showed no acute toxicity at any location other than site #3. There was slightly less growth of polychaetes for outer lagoon site #5 and outside the lagoon at site #6, suggesting a low level of chronic toxicity to this species. The two bioassay "hits" at sites #5 and #6 are considered an exceedance of CSLs.

Bioassays were not conducted at sites #1 and #2 adjacent to Whitmarsh, but historical data show toxicity to the amphipod *Rhepoxynius abronius*. The historical data also indicate there is some toxicity in sediments outside the lagoon

Recommendations

- Two sediment station clusters of potential concern are present in Padilla Bay Lagoon: sites #1, #2, and #3 for 2-methylphenol, 4-methylphenol, and 2,4-dimethylphenol, and sites #3 - #6 for the echinoderm bioassay. Based on these results, Ecology's Sediment Management Unit should score the sites for inclusion on the Contaminated Sediments Site List and evaluate as a priority for cleanup activities.

- Investigate the areal extent and cause of sediment toxicity at the head of Padilla Bay.

- Pursue remediation of Whitmarsh Landfill.

Introduction

The abandoned Whitmarsh Landfill is located on tidelands at the west end of Padilla Bay Lagoon at the head of Padilla Bay (Figure 1). The site, also known as the March Point Landfill, was used as an unregulated public dump from the 1950s to 1973. From 1961 to 1973 it was operated by Skagit County Public Works, then closed and covered with two to three feet of soil. The land is now under Department of Natural Resources jurisdiction. A sawmill had been built over the landfill but burned down in July 1998.

It is not known what types or quantities of wastes are buried at Whitmarsh. Four major industries were in operation at nearby March Point during the life of the fill: the Texaco and Shell petroleum refineries, Allied Chemical, and Northwest Petro-Chemical (now Technol). Of these, Texaco and Northwest Petrochemical are known to have dumped substances at the landfill. Because the site was unregulated for ten years and not strictly regulated after that, and because it was the most convenient county dump to March Point, other industrial wastes may have been disposed of here (Ecology, 1984; Milham, 1986).

During the summer of 1998, in response to a request from the Swinomish Tribal Community, the Washington State Department of Ecology (Ecology) Environmental Assessment Program conducted an investigation to determine the extent to which Padilla Bay Lagoon has been degraded by discharges from Whitmarsh Landfill. The Swinomish Indian Reservation includes part of the lagoon.

The Tribe had long been concerned about oily, discolored sediments near the fill and reported that petroleum sheens and odors commonly occur in the lagoon. Although previous sampling had not detected significant chemical contamination, the Tribe considered the data to be inconclusive (Rich, 1998).

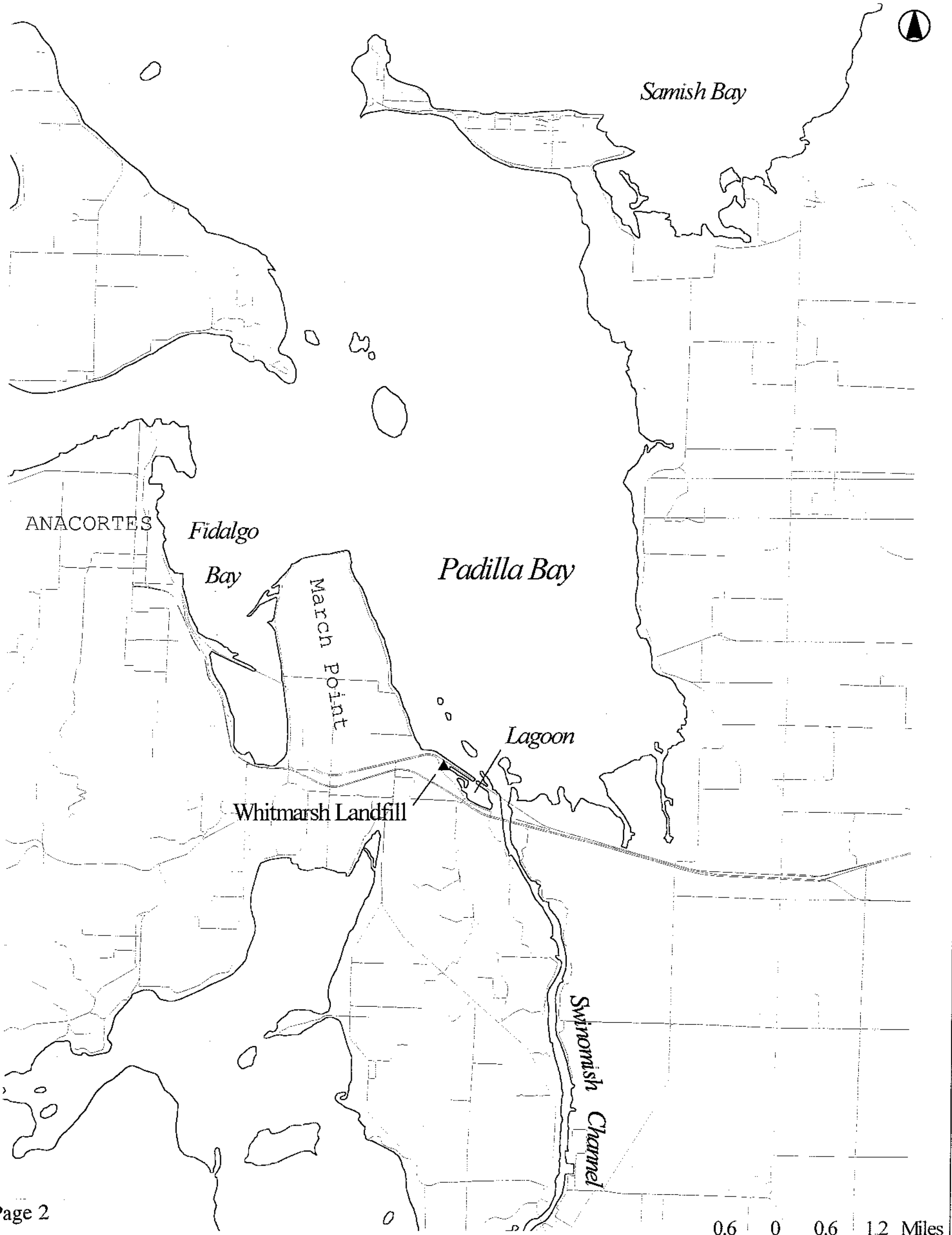


Figure 1. Whitmarsh Landfill, Padilla Bay Lagoon, and Vicinity

Previous Sampling

Table 1 lists the types of chemical and biological data that have been obtained from past investigations at Whitmarsh. Approximate sampling locations for these efforts are shown in Figure 2.

The general conclusion reached from these studies has been that the level of chemical contamination in Padilla Bay Lagoon is low and not readily traceable to the landfill. However, results of toxicity tests on the lagoon sediments seem to contradict these findings. A brief summary of the historical data follows:

In December 1985, Milham (1986) conducted an inspection of Whitmarsh Landfill for the Ecology Hazardous Waste Cleanup Program. Water and sediment samples were collected at the base of the landfill and at the opposite end of the lagoon. Milham concluded there was a "slight amount of contamination" by arsenic, toluene, and fluoranthene in sediments near the landfill, but could not determine if the landfill was the source. Nothing of significance was found in the water samples. Milham recommended that no further sampling or remedial action be required.

As part of a larger study on trace elements, petroleum, and chlorinated pesticides in Padilla and Fidalgo bays, the U.S. Fish and Wildlife Service analyzed a sediment sample collected from the inner lagoon in July 1988 (USFWS, 1994). Concentrations of metals and polyaromatic hydrocarbons (PAH) were within Ecology's sediment management standards (SMS; WAC 173-204). No petroleum contamination was indicated.

The Ecology Northwest Regional Office analyzed priority pollutant metals in a June 1988 sample of leachate flowing from the southeast corner of the landfill (Fitzpatrick, 1989). Cadmium, copper, lead, nickel, and zinc substantially exceeded marine water quality criteria, prompting a recommendation for further study. This finding has not been confirmed by other sampling at Whitmarsh.

During September 1988, Ecology analyzed phenolic compounds and polychlorinated biphenyls (PCBs) in two sediment samples from the lagoon (Johnson, 1989). 2-Methylphenol had been identified as the principal ground water contaminant at the Northwest Petrochemical facility which, as previously mentioned, had dumped wastes in Whitmarsh Landfill. One composite sediment sample was analyzed near the landfill and another at the lagoon outlet. The only compound detected was 4-methylphenol in the outlet sample at a relatively low concentration of 25 ug/Kg (parts per billion).

The most thorough chemical analysis previously conducted at Whitmarsh was by the Skagit County Departments of Health and Public Works (Willis, 1996). Responding to a complaint from the Swinomish Tribe, they analyzed priority pollutants in two samples each of landfill seepage and nearby lagoon sediments collected in October 1996. A

Table 1. Data Obtained from Previous Sampling at Whitmarsh Landfill/Padilla Bay Lagoon

Date	Investigator	Reference	Sample Type	N	Metals	Volatiles	Semivolatiles	OC Pesticides	PCBs	Bioassay
1985	Ecology	Milham (1986)	water	3	x	x	x	x	x	
	"	" "	sediment	2		x	x			
1988	USFWS	USFWS (1994)	sediment	2	x		x[1]	x		
1988	Ecology	Fitzpatrick (1989)	water	1	x					
1988	Ecology	Johnson (1989)	sediment	2			x[2]		x	
1990	WW Univ	Wiggins (1992)	sediment	3						x
1991	Padilla Reserve	Bulthuis & Shaw (1992)	sediment	4						x
1996	Skagit County	Willis (1996)	water	2	x[3]	x	x	x	x	
	" "	" "	sediment	2	x[3]	x	x	x	x	
1997	Swinomish Tribe	unpublished	water	1	x[3]	x	x	x	x	

[1] aliphatic hydrocarbons also analyzed

[2] phenolic compounds only

[3] cyanide also analyzed

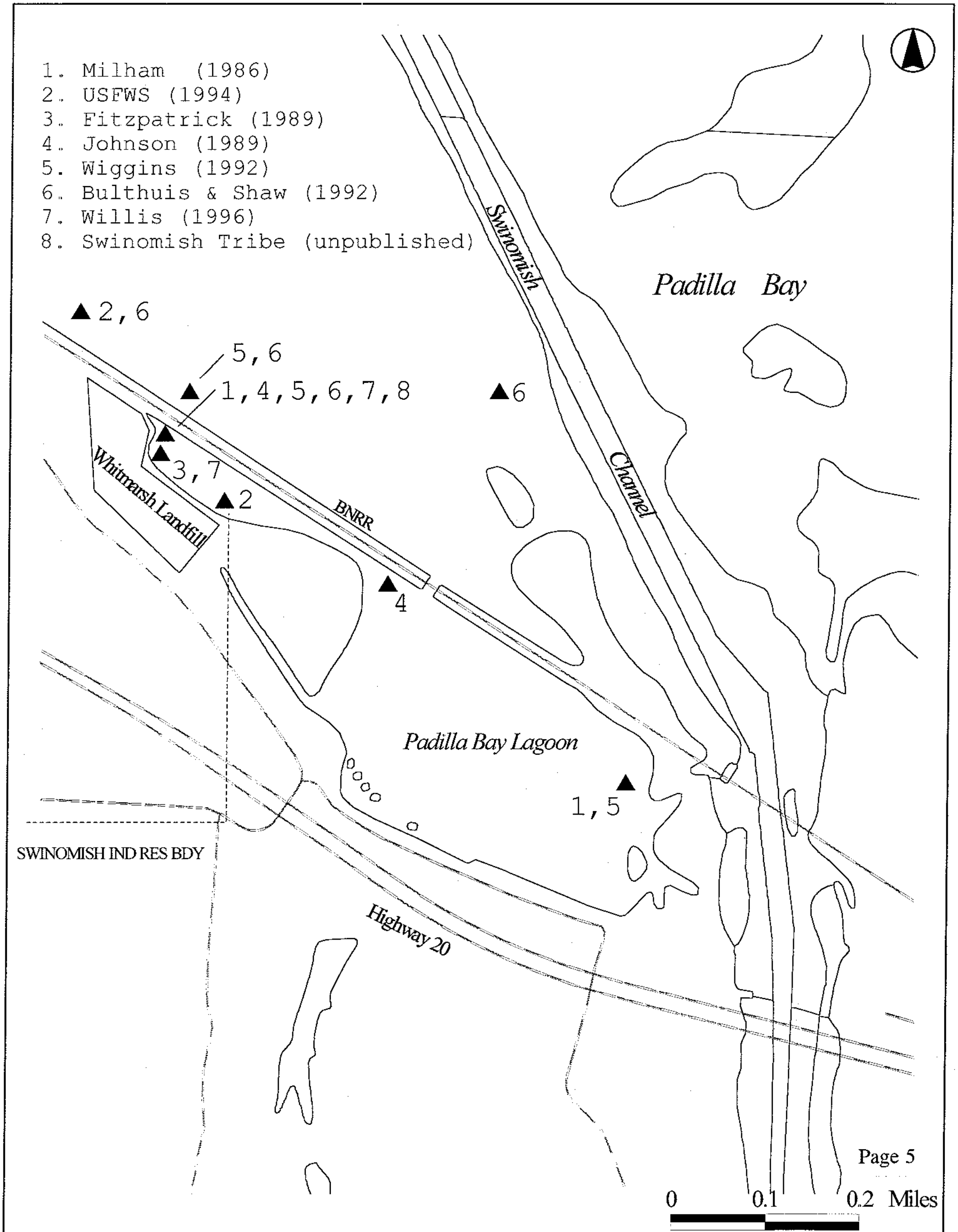


Figure 2. Approximate Location of Previous Samples in Padilla Bay Lagoon

number of volatile and semivolatile organic compounds were detected but the levels were low (Table 2). Based on these results it was concluded that further investigation by the county was not warranted.

Most recently, the Swinomish Tribe analyzed priority pollutants in a lagoon water sample taken near the landfill in September 1997. No organic compounds were detected and metals concentrations were low (unpublished data provided by Aundrea Noffke, Office of Planning and Community Development, Swinomish Tribal Community).

Bioassays with the amphipod crustacean *Rhepoxynius abronius* were conducted on Padilla Bay Lagoon sediments by Wiggins (1992) and Bulthuis & Shaw (1992), Ecology Padilla Bay National Estuarine Research Reserve. Sediments were tested from three or four sites located in and just outside the lagoon (Figure 3). Although significant mortality was found in all areas relative to controls, the most toxic sediments were adjacent to the landfill (sites A and C in Figure 3). Wiggins reported the sediments at site C were oily. The least toxic sediments were at the far east end of the lagoon (B) and north of the lagoon (E). Bulthuis & Shaw (1992) also found scattered sediment toxicity in a wider area of Padilla Bay.

Table 2. Skagit County Data for Whitmarsh Landfill Intertidal Samples Collected in 1996
[Organics data includes detected compounds only.]

Sample Type:	Seepage		Sediment	
Location:	N. end	S. end	N. end	S. end
Date:	24-Oct	24-Oct	24-Oct	24-Oct
Sample Number:	WMW-1	WMW-2	WM-1	WM-2
Priority Pollutant Metals (ug/L or mg/Kg, dry)				
Antimony	6 U	6 U	1 U	2 U
Arsenic	5 U	5 U	**12**	**11**
Beryllium	10 U	10 U	0.5 U	0.6 U
Cadmium	10 U	10 U	**1.3**	**1.8**
Chromium	10 U	10 U	**44**	**49**
Copper	10 U	10 U	**47**	**39**
Lead	50 U	50 U	**26**	**27**
Mercury	0.2 U	0.2 U	0.1 U	**0.3**
Nickel	20 U	20 U	**50**	**51**
Selenium	5 U	5 U	**0.8**	0.2 U
Silver	10 U	10 U	0.9 U	1.3 U
Thallium	1 U	1 U	0.2 U	0.4 U
Zinc	**26** U	**31** U	**85**	**110**
Cyanide (ug/L or mg/Kg, dry)	5 U	5 U	0.2 U	0.6 U
Volatile Organic Compounds (ug/L or ug/Kg, dry)				
Benzene	**6**	**2** J	nd	nd
Chlorobenzene	**15**	**1** J	nd	nd
Toluene	**2** J	3 U	**8** J	**11** J
m & p-Xylene	**3**	**1** J	**5** J	**8** J
o-Xylene	**3**	3 U	nd	nd
2-Butanone	5 U	5 U	**170**	**190**
4-Methyl-2-pentanone	5 U	5 U	**100**	nd
2-Hexanone	5 U	5 U	**38** J	**36** J
Acetone	5 U	5 U	**520**	**700**
Methylene Chloride	3 U	3 U	**14** J	**16** J

Note: Detections indicated in **bold.**
U = Not detected at or above reported value (i.e., less than)
J = The analyte was positively identified; associated numerical value is an estimated.

Table 2. Skagit County Data (continued)

Sample Type:	Seepage		Sediment	
Location:	N. end	S. end	N. end	S. end
Date:	24-Oct	24-Oct	24-Oct	24-Oct
Sample Number:	248005	248006	248007	248008
Low Molecular Weight Polyaromatic Hydrocarbons (ug/L or ug/Kg, dry)				
Naphthalene	**2**	1 U	60 U	100 U
2-Methylnaphthalene	**1**	1 U	60 U	100 U
High Molecular Weight Polyaromatic Hydrocarbons (ug/L or ug/Kg, dry)				
Fluoranthene	1 U	1 U	**46** J	100 U
Pyrene	1 U	1 U	**84**	100 U
Benzo(a)anthracene	1 U	1 U	**74**	100 U
Chrysene	1 U	1 U	**64**	100 U
Benzo(b)fluoranthene	1 U	1 U	**48** J	100 U
Benzo(k)fluoranthene	1 U	1 U	**30** J	100 U
Phenols (ug/L or ug/Kg, dry)				
2,4-Dimethylphenol	**3**	1 U	60 U	100 U
Phthalate Esters (ug/L or ug/Kg, dry)				
Bis(2-ethylhexyl)phthalate	1 U	**1**	**100**	**440**
Miscellaneous Semivolatiles (ug/L or ug/Kg, dry)				
N-Nitrosodiphenylamine	1 U	**1**	60 U	100 U
Polychlorinated Biphenyls	nd	nd	nd	nd
Organochlorine Pesticides	nd	nd	nd	nd

nd = None detected

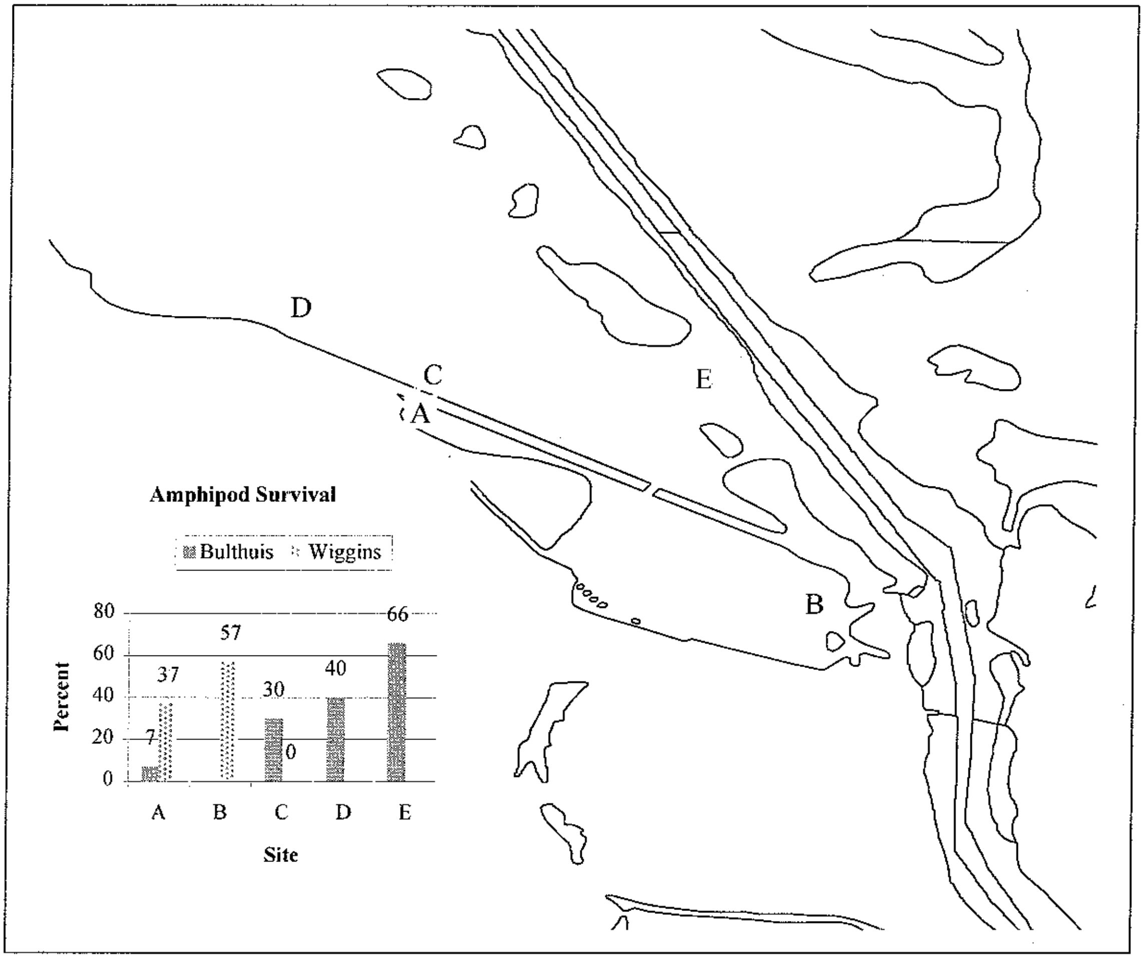


Figure 3. Results of Amphipod (*R. abronius*) Bioassays on Padilla Bay Lagoon Sediment [from Bulthuis & Shaw (1992) and Wiggins (1992)]

Study Description

Ecology's 1998 investigation into the effects of Whitmarsh Landfill on Padilla Bay Lagoon was done in two stages: An extensive chemical screening was first conducted on samples of seepage and intertidal sediments at the base of the landfill. Based on these results, a wider survey was conducted of sediment quality in the lagoon, focusing on chemicals detected in the screening analysis.

Chemical Screening

The objectives of the screening survey were to identify chemicals of potential concern to marine life and human health, and to determine what, if any, additional sampling should be conducted in the lagoon.

The screening samples were collected at low tide on June 11, 1998 at sites #1 and #2 shown in Figure 4. These are the same locations sampled by Skagit County in 1996. Water samples were taken as simple grabs from the two largest flows coming out of the landfill. The sediment samples were composites of multiple grabs taken along a 20 - 30 foot transect downstream of the water samples and roughly parallel to the face of the fill. Representatives from the Swinomish Tribal Community, Skagit County Departments of Health and Public Works, and the Ecology Northwest Regional Office assisted with the field work.

The Ecology/EPA Manchester Environmental Laboratory (MEL) analyzed the samples for approximately 400 potentially toxic chemicals (Table 3). So as not to overlook any contaminant of interest, low detection limits were employed and major peaks of non-target compounds were identified. This constitutes the most thorough set of chemical analyses so far conducted at Whitmarsh. Conventional water quality data were also obtained on the seepage.

Petroleum and a series of organic compounds — including but not limited to chlorinated benzenes, PAH, phenols, and PCBs — were identified as chemicals of potential concern in the screening analysis. The levels of contamination in seepage were generally low and unlikely to cause toxicity in the lagoon water column. Therefore, further water sampling was not conducted. However, many of the compounds detected in the seepage tend to be absorbed by sediments, and the sediment samples showed elevated levels for a number of these. SMS cleanup screening levels were exceeded for methylphenols. In light of these findings, a wider evaluation of sediment quality in the lagoon appeared warranted.

Table 3. Analysis of Whitmarsh Landfill/Padilla Bay Lagoon Samples Collected in 1998
(Number of chemicals or chemical mixtures analyzed shown in parenthesis)

Date:	June 11		August 7
Site Numbers:	1, 2		3, 4, 5, 6, ref. area
Sample Type:	Seepage	Sediment	Sediment
Chemistry			
Priority Pollutant Metals (13)	x	x	x
Metals Scan (26)	x	x	
Cyanide	x		
Total Petroleum Hydrocarbons	x	x	x
Hydrocarbon Identification	x	x	
Volatile Organics (81 + TIC[1] search)	x		x
Semivolatile Organics (84 + TIC search)	x	x	x
Polychlorinated Biphenyls (7)	x	x	x
Pesticides (129)	x	x	
Herbicides (25)	x	x	
GC/AED[2] Screen	x	x	
Polychlorinated Dioxins and -Furans (17)		x	x
Organotins (4)		x	
Bioassays			
Amphipod 10-day Mortality			x
Echinoderm 4-day Mortality/Abnormality			x
Polychaete 20-day Biomass			x

[1]Tentatively Identified Compounds

[2]Gas Chromatography/Atomic Emissions Dectection

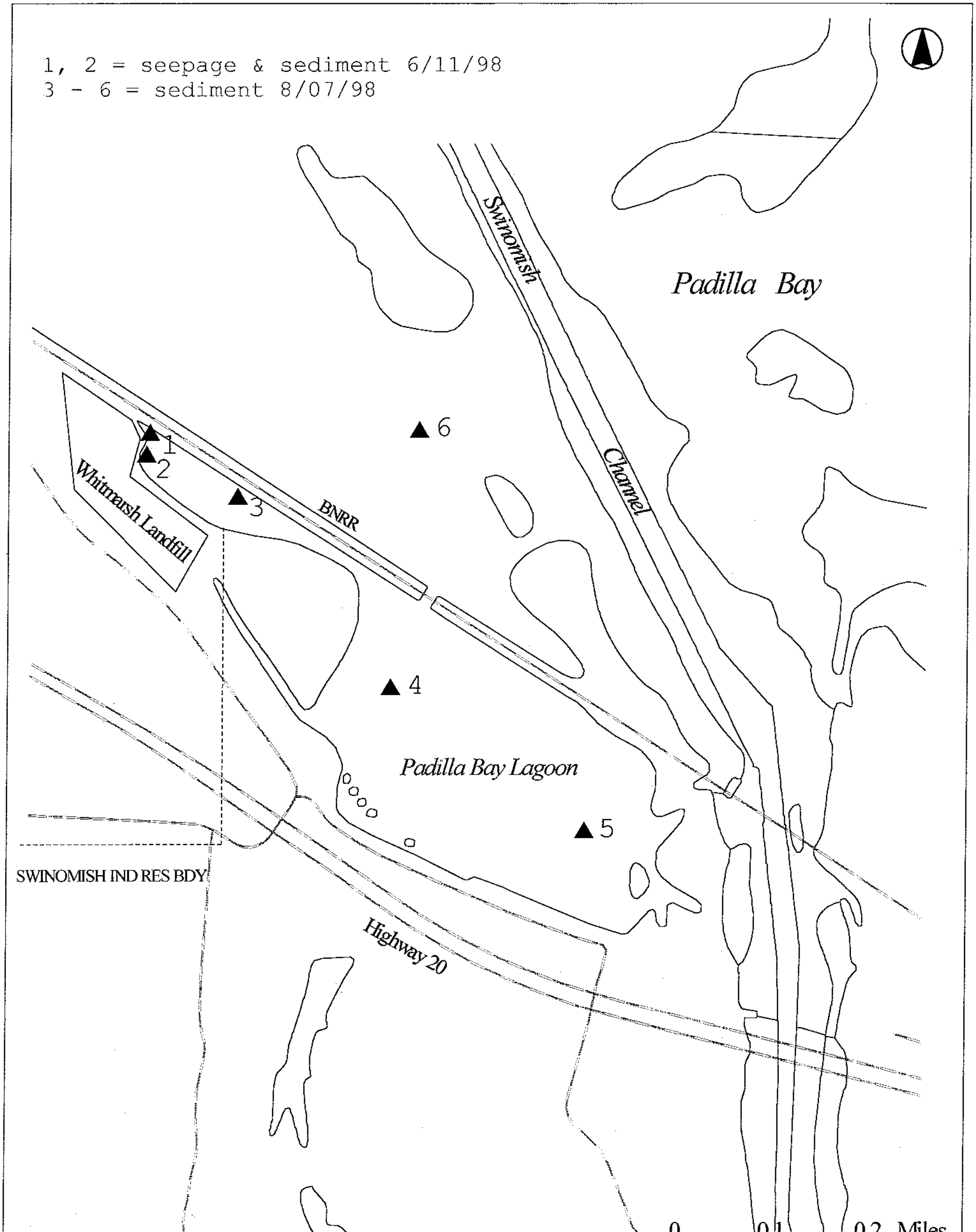


Figure 4. Location of Department of Ecology Samples Collected in 1998

Sediment Survey

Field work for the expanded sediment survey was done on August 7, 1998. The objectives were to:

- Determine the occurrence of chemicals of potential concern
- Determine the extent of contamination
- Assess compliance with the SMS chemical and biological criteria
- Evaluate the significance of contamination by non-SMS chemicals
- Draw conclusions about probable sources of contamination

Composite sediment samples were collected at three sites farther out in the lagoon – #3 in the inner lagoon, and #4 and #5 in the outer lagoon – and one site (#6) outside the lagoon in Padilla Bay (Figure 4). Sediments were also collected from an established reference area nine miles to the north in Samish Bay (Figure 5). Sediments at this location have been shown to have a low level of chemical contamination and no significant toxicity (PTI, 1991). Representatives from the Swinomish Tribal Community assisted in collecting samples from the lagoon.

The August samples were analyzed for a subset of the screening survey chemicals and also subjected to bioassays (Table 3). Chemical analysis included total petroleum hydrocarbons (TPH), metals, volatile organic compounds, semivolatile organic compounds, PCBs, and polychlorinated dibenzo-p-dioxins and -furans (PCDDs/PCDFs). The normalizing parameters total organic carbon (TOC), grain size, and aluminum were also determined.

Confirmatory bioassays were conducted to evaluate the toxicity of sediments that passed or failed the SMS chemical criteria. As directed in the standards, two acute effects bioassays and one chronic effects bioassay were done. The acute bioassays were the 10-day amphipod crustacean mortality test with *Ampelisca abdita*, and the 4-day echinoderm larvae mortality/abnormality test with the sea urchin *Stongylocentrotus purpuratus*. *Ampelisca* was selected over the two other possible amphipod test species, *Rhepoxynius abronius* and Eohaustorius estuarius, as being more appropriate for the fine grain size and saline conditions in the lagoon (PSEP, 1995). The chronic test was the 20-day juvenile polychaete worm growth test with *Neanthes arenaceodentata*.

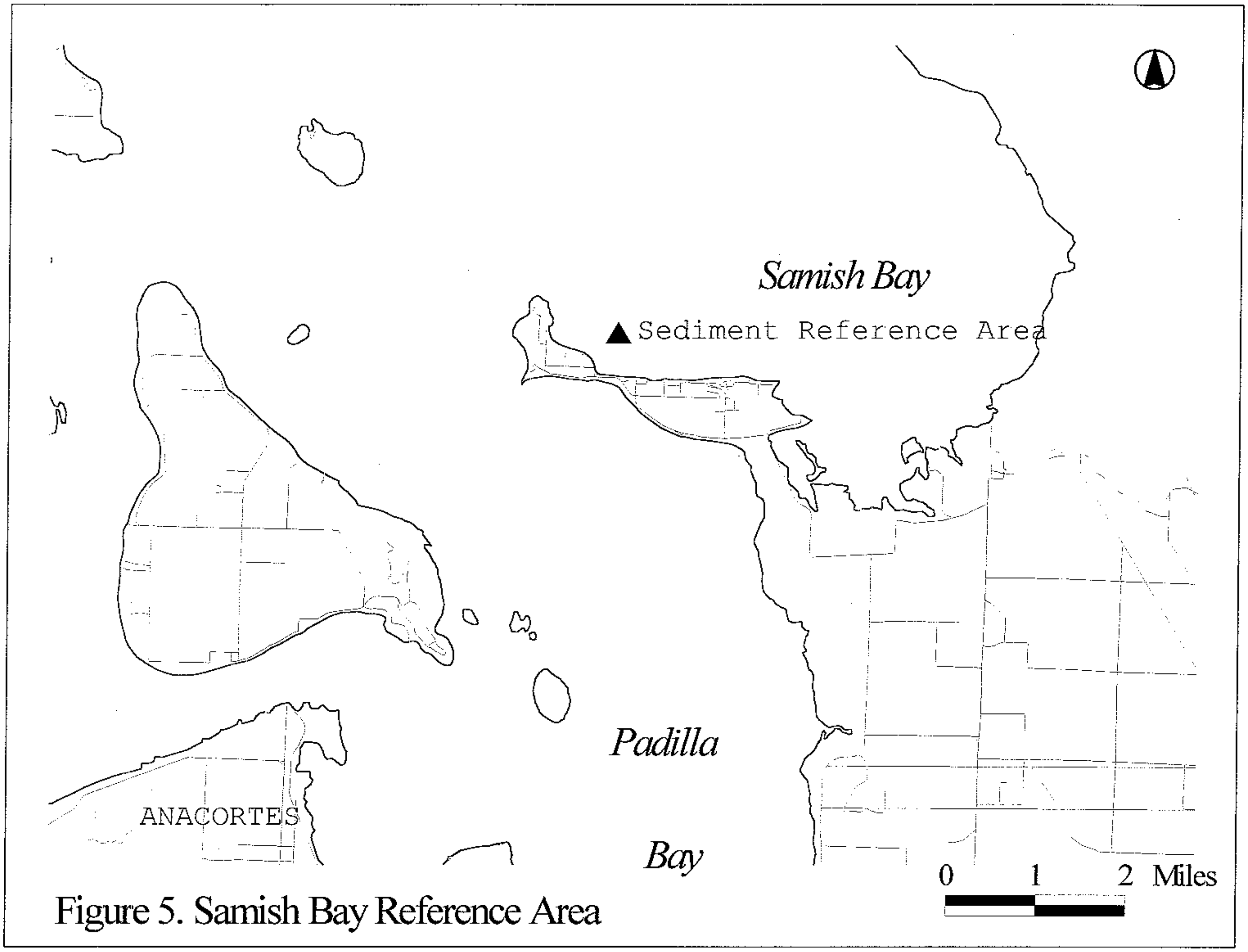


Figure 5. Samish Bay Reference Area

Sampling Methods

Water

Water samples were taken by hand as simple grabs using glass or polyethylene containers appropriate to each analysis, as described in MEL (1994). The samples were placed in bubble-wrap and polyethylene bags, stored on ice, and transported to MEL within one day of collection. Chain-of-custody was maintained.

Sediment

Sediment sampling methods followed PSEP (1996) protocols and SMS requirements (Ecology, 1995a,b). The June samples were collected by hand using a stainless steel bucket on the end of an aluminum pole. The August samples were collected with a 0.05 m^2 stainless steel Ponar grab. A grab was considered acceptable if not over-filled with sediment, overlying water was present and not excessively turbid, the sediment surface relatively flat, and desired depth penetration had been achieved.

For the June survey, between five and ten individual grabs were composited for each sediment sample. The August samples were three-grab composites. In each case, approximately the top 10-cm surface layer was taken for analysis. Ecology considers this to represent the "biologically active zone" (Ecology, 1995b). The sites sampled in June were identified by Skagit County personnel so as to coincide with their 1996 survey. Sampling sites for August were located using visual fixes and a Magellan GPS. Appendix A has the GPS coordinates.

After draining off overlying water, sediments were removed from the sampler with a stainless steel scoop, placed in a stainless steel bucket, and homogenized by stirring. Subsamples of the homogenate were placed in glass jars with teflon lid liners, cleaned to EPA QA/QC specifications (EPA, 1990), or Whirl-Pak bags for grain size.

Stainless steel scoops and buckets used to manipulate the sediments were cleaned by washing with Liquinox detergent, followed by sequential rinses with tap water, dilute nitric acid, deionized water, and pesticide-grade acetone. The equipment was then air-dried and wrapped in aluminum foil. The same procedures were used to pre-clean the grab before going into the field. Between-sample cleaning of the grab consisted of thorough brushing and rinsing with on-site water. Dedicated grab samplers were used in June.

The sediment samples were placed in bubble-wrap and polyethylene bags, stored on ice, and transported to MEL within one day of collection. Chain-of-custody was maintained (Appendix B)

Analytical Methods

Sample analysis was conducted by MEL or certified contract laboratories selected by MEL. Methods of analysis are listed in Table 4.

Data Quality

Chemistry

MEL prepared written reviews on the quality of the chemical 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 and reference material, surrogate recoveries, matrix spike recoveries, and duplicate sample analyses. The reviews and complete chemical data are available as a separate data appendix.

Overall, the quality of the data is good. Some results were qualified as estimates because concentrations in the field samples, although detectable, were below the method quantitation limit

As described below, all QA/QC requirements were not met for certain analytes, which resulted in further qualification of some data. In most instances, the net effect of these shortcomings is to increase the possibility that the reported concentration is an underestimate.

June Data

Due to low matrix spike recoveries (8-17%) the antimony data on sediment samples were qualified as undetected at an estimated detection level (UJ flag). Results for strontium in these samples were qualified as estimates (J flag) due to marginally low recovery in one of two matrix spikes (68% vs. 75% acceptance limit).

Recoveries of PCB surrogate compounds were low for the water samples (28-40%). The PCB concentrations detected in these samples were qualified as estimates.

Due to an oversight at the laboratory, water samples for carbamate insecticides substantially exceeded holding times before being analyzed (111 days vs. 28 days). The results were qualified as estimates. MEL has conducted a holding study for carbamates that shows no significant degradation occurs during the first six months in a properly preserved and stored sample (Steve Reimer, unpublished EPA data). The lone detection of a carbamate pesticide in these samples was confirmed in a separate analysis for nitrogen-containing pesticides, done within holding time (see Results and Discussion).

Table 4. Analytical Methods for Whitmarsh Landfill/Padilla Bay Lagoon Samples Collected in 1998

Analyte(s)	Method	Number	Reference	Laboratory
Water Samples*				
Petroleum Hydrocarbons (WTPH-Dx)	MeCl extraction/GC/FID	8000, 8015, 5030**	SW-846	Manchester
Petroleum Hydrocarbons (WTPH-G)	MeCl extraction/GC/FID	8000, 8015, 5030**	SW-846	Manchester
Hydrocarbon ID (WTPH-HCID)	MeCl extraction/GC/FID	- -	in-house	Manchester
Semivolatiles	MeCl extraction/GC/MS	8270	SW-846	Manchester
Volatiles	Purge + trap/GC/MS	8260	SW-846	Manchester
Polychlorinated Biphenyls	MeCl extraction/GC/ECD	8080	SW-846	Manchester
Neutral Pesticides	MeCl extraction/GC/AED	8085	SW-846	Manchester
Carbamate Pesticides	HPLC	531.1	SW-846	Manchester
Herbicides	MeCl extraction/GC/AED/ITD	8085	SW-846	Manchester
Cyanide	Weak acid /colorimetry	4500CNC	SM-17	Manchester
Metals Scan	HNO^3,HCl digestion/ICP	200.7	EPA (1983)	Manchester
Mercury	CVAA	245.1	EPA (1983)	Manchester
Sediment Samples				
Petroleum Hydrocarbons (WTPH-Dx)	MeCl extraction/GC/FID	8000, 8015, 5030**	SW-846	Manchester
Petroleum Hydrocarbons (WTPH-G)	MeCl extraction/GC/FID	8000, 8015, 5030**	SW-846	Manchester
Semivolatiles	MeCl extraction/GC/MS	8270	SW-846	Manchester
Volatiles	Purge + trap/GC/MS	8260	SW-846	Manchester
Polychlorinated Biphenyls	Acetone extraction/GC/ECD	8080	SW-846	Manchester
Neutral Pesticides	Acetone extraction/GC/AED/ITD	8085	SW-846	Manchester
Herbicides	Diethylether extract./GC/AED/ITD	8085	SW-846	Manchester
Polychlorinated Dioxins & -Furans	Extraction/high res. GC/MS	1613b (6/98 samples)	SW-846	Triangle
Polychlorinated Dioxins & -Furans	Extraction/high res. GC/MS	8290 (8/98 samples)	SW-846	MAXIM/Pace
Organotins	Extraction/GC/MS(SIM-mode)	PSEP Method	PSEP (1996)	Manchester

Table 4. Analytical Methods (continued)

Analyte(s)	Method	Number	Reference	Laboratory
Sediment Samples (continued)				
Metals Scan	HNO^3,HCl digestion/ICP	200.7	EPA (1983)	Manchester
Priority Pollutant Metals	HNO^3,HCl digestion/ICP	200.7	EPA (1983)	Manchester
Arsenic	HNO^3,HCl digestion/GFAA	206.2	EPA (1983)	Manchester
Lead	HNO^3,HCl digestion/GFAA	239.2	EPA (1983)	Manchester
Selenium	HNO^3,HCl digestion/GFAA	7740	SW-846	Manchester
Thallium	HNO^3,HCl digestion/GFAA	279.2	EPA (1983)	Manchester
Mercury	CVAA	245.5	EPA (1983)	Manchester
Total Organic Carbon	Persulfate/UV Ox./FID	PSEP Method	PSEP (1996)	Manchester
Grain Size	Sieve & pipette	PSEP Method	PSEP (1996)	Rosa
Amphipod Bioassay (*A. abdita*)	10-day survival & emergence	PSEP Method	PSEP (1995)	Ogden
Polychaete Bioassay (*Neanthes*)	20-day survival & growth	PSEP Method	PSEP (1995)	Ogden
Echinoderm Bioassay (*S. purpuratus*)	4-day normal survivorship	PSEP Method	PSEP (1995)	Ogden

Note: PCDD/PCDF methods 1613b and 8290 differ in the number of internal standards used and how detection limits are calculated.
*Conventional water quality analyses followed routine methods described in MEL (1994)
**As modified by Manchester Laboratory

Matrix spike recoveries of tetrabutyltin were below 5% and the data were rejected.

August Data

Mercury analysis of the sediment samples exceeded the 28-day holding time by 7 days. The mercury data for these samples were qualified as estimates

Spike recoveries for antimony (15-19%) and thallium (57-59%) were low in sediment and were UJ qualified. Antimony and silver recoveries were also low in a laboratory control sample (49% and 58%, respectively). The silver data were qualified UJ where not detected or as estimates when above the detection limit. No further qualification was necessary for antimony.

Results for some volatile and semivolatile compounds in sediment samples were qualified as estimates due to matrix spike recoveries below 50%.

Matrix spike recoveries in sediment were below 10% and no useful data obtained for the semivolatiles aniline, 4-chloroaniline, and hexachlorocyclopentadiene. Results for benzoic acid in these samples were also not useable because of problems with instrument calibration

High concentrations of volatiles in sediment sample #328004 required dilution and re-analysis, resulting in the 14-day holding time being exceeded by 4 days.

Non-detects for 1,2,3,4,5,6,7-heptachlorodibenzofuran in sediment were UJ qualified due to internal standard recoveries below 40%. All 2,3,7,8-substituted dioxin and -furan congeners in these samples were qualified as estimates because the relative percent difference in a duplicate analysis of sample #328000 exceeded 25% (45 - 81%). The poor precision achieved on this sample (Samish Bay reference sediment) is a function of the extremely low levels being measured. Precision of matrix spike and spike duplicates for this sample set was within the 20% acceptance window.

Toxicity Tests

Quality assurance (QA) procedures for the sediment bioassays are described in the toxicity testing report prepared by the contract laboratory (Ogden, 1998) and can be summarized as follows:

Test organisms were collected in areas known to be generally free of pollutants, from which quality animals had previously been collected or purchased from biologists knowledgeable about the organisms. Upon receipt at the laboratory, the animals were slowly acclimated to test conditions in environmentally controlled holding areas, in accordance with each test protocol.

The laboratory implemented all applicable QA procedures for source, handling, receipt, and storage of samples and test organisms, as well as calibration and maintenance of instruments and equipment used during testing. Laboratory negative controls and positive controls (reference toxicants) were included with each sediment bioassay. The negative controls consisted of sediment from the amphipod collection site (amphipod and polychaete bioassays) and/or clean, filtered seawater without sediment (polychaete and echinoderm bioassays). Reference toxicants were $CdCl^2$ or $CuCl^2$. Water quality (dissolved oxygen, pH, salinity, temperature, ammonia, and hydrogen sulfide) were monitored during the bioassays. These tests confirmed quality and sensitivity of the test organisms, sound laboratory conditions, and appropriateness of procedures.

Positive and negative controls and the reference sediment met performance standards specified for these tests by the Puget Sound Estuary Program.

Results and Discussion

Screening Survey

Field Observations

The weather was dry at the time of the survey. During the previous 24 hours there had been 0.2 inches of rainfall, with no measurable precipitation for the preceding week.

A diffuse and generally light seepage was flowing out of Whitmarsh Landfill onto the lagoon mudflats. The two largest seeps in the areas previously sampled by Skagit County were selected for sampling (see Skagit County photos, Figure 6). Flows were estimated to be 0.01 cfs or less.

A slight petroleum odor was evident in the vicinity of the landfill. The sediments had petroleum sheen in some locations, particularly in the northwest corner of the lagoon at site #1. The seepage samples appeared free of sheen.

Sediments near the fill had a thin, oxidized surface layer stained reddish-brown by the iron-rich seepage. This was underlain by black anoxic sediments that smelled strongly of hydrogen sulfide. In places, bubbles percolating up through the sediments had exposed the anoxic layer, giving the impression of oil spots.

General Water Quality

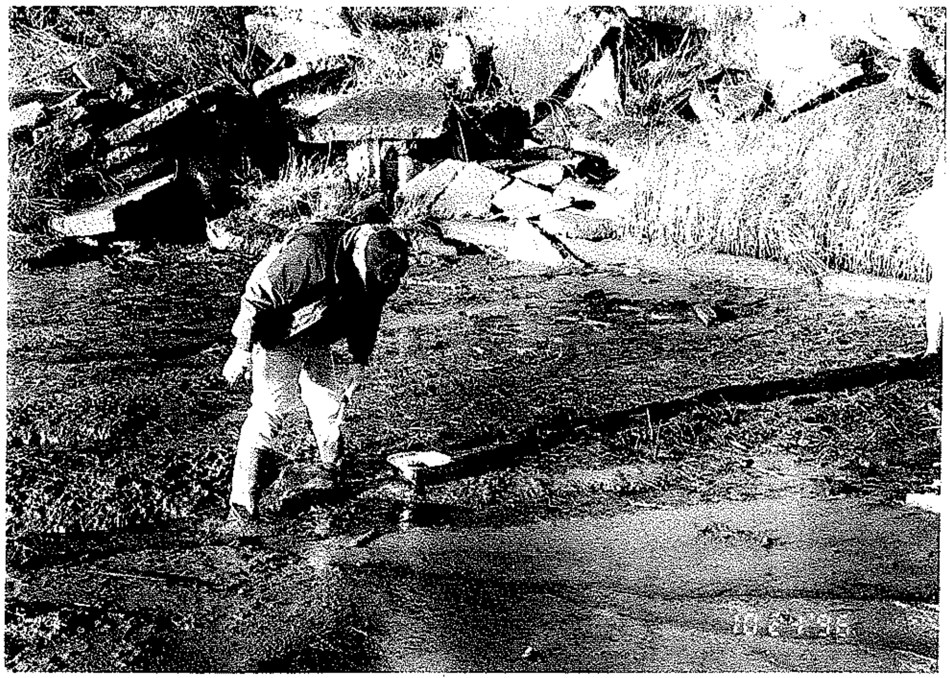
The two seeps appeared to be of similar quality (Table 5). There was no measurable salinity in either discharge, indicating it was fresh water rather than from tidal incursions into the landfill. The water samples were collected near lower low water, between 1130 and 1200 hours; high tide was +7.4 ft at 0454 hours and the low was -2.1 ft. at 1247 hours.

Whitmarsh seepage was dilute compared to typical landfill leachate (Kmet, 1982; EPA, 1987). The pH was neutral and the levels of suspended solids, turbidity, and nutrients relatively low. Nitrogen was in the ammonia form, rather than nitrate/nitrite, because of the reduced, anaerobic nature of the fill. Phosphorus concentrations tend to be low in landfill leachate as a result of being tied up with fill materials.

Chemicals Detected

Table 6 summarizes results from the chemical screening. Appendix C has the complete list of chemicals analyzed for this project. With few exceptions, the number and levels of contaminants detected in the seepage and sediment samples compared closely between

Ecology Site #1, looking west from BNRR tracks



Ecology Site #1, Skagit County sediment sampling

Figure 6A. Skagit County Photos of Whitmarsh Landfill, from October 1996 Survey (courtesy of Britt Pfaff, Skagit County Department of Health)

Ecology Site #2, looking north at BNRR tracks.

Ecology Site #2, Skagit county sediment sampling

Figure 6B. Skagit County Photos of Whitmarsh Landfill, from October 1996 Survey (courtesy of Britt Pfaff, Skagit County Department of Health).

Table 5. Water Quality of Whitmarsh Intertidal Seepage Collected June 11, 1998

Site Number:	1	2
Date:	11-Jun	11-Jun
Sample Number:	248005	248006
Salinity (ppt)	0 0	0.0
Conductivity (umhos/cm)	**1240**	**1020**
pH (lab)	**8.0**	**8.0**
Total Suspended Solids (mg/L)	**25**	**30**
Turbidity (NTU)	**26**	**190**
Ammonia (mg/L)	**3.2**	**6.8**
Nitrite-Nitrate (mg/L)	0.01 U	0.01 U
Phosphorus (mg/L)	**0.17**	**0.25**
Total Organic Carbon (mg/L)	**12**	**9.3**

U = Not detected at or above reported value (i.e., less than)

Table 6. Chemicals Detected in Whitmarsh Intertidal Samples Collected June 11, 1998
[Volatiles, semivolatiles, and pesticides show detected compounds only.]

Sample Type:	Seepage		Sediment	
Site Number:	1	2	1	2
Sample Number:	248005	248006	248007	248008
Priority Pollutant Metals (ug/L or mg/Kg, dry)				
Antimony	30 UJ	30 U	3 UJ	3 UJ
Arsenic	30 U	30 U	**11**	**12**
Beryllium	1 U	1 U	**0.39**	**0.40** U
Cadmium	4 U	4 U	0.5 U	0.5 U
Chromium	5 U	5 U	**65**	**59**
Copper	5 U	5 U	**44**	**39**
Lead	20 U	20 U	**13**	**13**
Mercury	0.05 U	0.05 U	**0.082**	**0.076**
Nickel	15 U	15 U	**51**	**42**
Selenium	40 U	40 U	**0.50**	**0.42**
Silver	4 U	4 U	0.4 U	0.4 U
Thallium	50 U	50 U	0.3 U	0.3 U
Zinc	5 U	5 U	**98**	**93**
Misc. Trace Elements (ug/L or mg/Kg, dry)				
Aluminum	**106**	**39**	**19900**	**19200**
Barium	**103**	**162**	**50**	**50**
Calcium	**43400**	**54500**	**6680**	**7240**
Cobalt	5 U	5 U	**8.8**	**9.1**
Iron	**5660**	**16200**	**47000**	**47500**
Magnesium	**37300**	**31400**	**13900**	**14000**
Manganese	**127**	**234**	**311**	**296**
Molybdenum	**7.4**	5 U	**3.1**	**3.1**
Potassium	**17400**	**15500**	**3380**	**3400**
Sodium	**137000**	**86200**	**20800**	**21300**
Strontium	**402**	**369**	**79** J	**94** J
Titanium	5 U	5 U	**1120**	**1170**
Vanadium	5 U	5 U	**68**	**66**
Cyanide (ug/L)	5 U	5 U	--	--

Note: Detections indicated in **bold**.
U = Not detected at or above reported value (i.e., less than)
J = The analyte was positively identified; associated numerical value is an estimated.
-- = Not analyzed.

Table 6. Whitmarsh June 1998 Chemicals (continued)

Sample Type:	Seepage		Sediment	
Site Number:	1	2	1	2
Sample Number:	248005	248006	248007	248008
Total Petroleum Hydrocarbons (ug/L or mg/Kg, dry)				
#2 Diesel	**850**	**470**	70 U	44 U
Lube Oil	80 U	80 U	180 U	**190***
Gasoline	120 U	120 U	34 U	38 U
Volatile Organic Compounds (ug/L)				
Benzene	**2.5**	**1.6**	--	--
Ethylbenzene	**0.10** J	1.0 U	--	--
Isopropylbenzene	**0.15** J	**0.29** J	--	--
Chlorobenzene	**0.55**	**0.92** J	--	--
1,2-Dichlorobenzene	**0.33** J	**0.28** J	--	--
1,4-Dichlorobenzene	**0.52** J	**0.42** J	--	--
1,2,4-Trimethylbenzene	**0.79** J	1 U	--	--
1,3,5-Trimethylbenzene	**0.14** J	1 U	--	--
Toluene	**0.86** J	**0.15** J	--	--
m & p-Xylene	**1.2** J	**0.41** J	--	--
o-Xylene	**1.3** J	**0.14** J	--	--
Naphthalene	**2.1**	1 U	--	--
Ethylether	1 U	**0.51** J	--	--
Low Molecular Weight Polyaromatic Hydrocarbons (ug/L or ug/Kg, dry)				
Naphthalene	**0.84**	**0.09** J	**66** J	**44** J
1-Methylnaphthalene	**0.49**	**0.52**	**50** J	**32** J
2-Methylnaphthalene	**0.39**	**0.28**	**87** J	**60** J
2,6-Dimethylnaphthalene	**0.10** J	**0.15**	**352**	**219**
1,6,7-Trimethylnaphthalene	0.12 U	**0.02** J	179 U	**37** J
Acenaphthene	**0.42**	**0.24**	**35** J	115 U
Flourene	**0.26**	**0.16**	**52** J	**29** J
Phenanthrene	**0.24**	**0.06** J	**198**	**112** J
1-Methylphenanthrene	0.12 U	**0.02** J	**287**	**234**
2-Methylphenanthrene	**0.04** J	**0.02** J	**61** J	**26** J
Anthracene	**0.04** J	**0.03** J	**64** J	**27** J

*Concentration was below quantitation limit (160 mg/Kg) in a duplicate analysis of this sample.

Table 6. Whitmarsh June 1998 Chemicals (continued)

Sample Type:	Seepage		Sediment	
Site Number:	1	2	1	2
Sample Number:	248005	248006	248007	248008
High Molecular Weight Polyaromatic Hydrocarbons (ug/L or ug/Kg, dry)				
Fluoranthene	**0.07** J	**0.02** J	**332**	**161**
Pyrene	**0.04** J	**0.04** J	**311**	**146**
Benzo(a)anthracene	**0.03** J	0.12 U	**123** J	**66** J
Chrysene	0.12 U	0.12 U	**240**	**112** J
Benzo(b)fluoranthene	0.12 U	0.12 U	**283**	**138**
Benzo(k)fluoranthene	0.25 U	0.25 U	**79** J	**40** J
Benzo(e)pyrene	0.12 U	0.12 U	**127** J	**72** J
Benzo(a)pyrene	0.25 U	0.25 U	**103** J	**35** J
Perylene	0.12 U	0.12 U	**263**	**123**
Indeno(1,2,3-cd)pyrene	0.62 U	0.62 U	**229** J	576 U
Benzo(g,h,i)perylene	0.12 U	0.12 U	**192**	**116**
Phenols (ug/L or ug/Kg, dry)				
Phenol	**0.08** J	0.12 U	**178** J	**271**
2-Methylphenol	**0.16**	0.25 U	**180**	**121**
4-Methylphenol	**0.30**	**0.10** J	**545**	**238**
2,4-Dimethylphenol	0.12 U	0.12 U	**288**	**118**
4-Chloro-3-methylphenol	**0.52**	0.12 U	179 U	115 U
Chlorinated Benzenes (ug/L or ug/Kg, dry)				
1,2-Dichlorobenzene	**0.18**	**0.13**	179 U	115 U
1,3-Dichlorobenzene	**0.01** J	0.25 U	359 U	231 U
1,4-Dichlorobenzene	**0.34**	**0.24**	179 U	115 U
Phthalate Esters (ug/L or ug/Kg, dry)				
Diethylphthalate	**0.19** J	**0.14** J	**25** J	576 U
Di-n-butylphthalate	0.12 U	0.12 U	**1380**	**698**
Bis(2-ethylhexyl)phthalate	0.12 U	0.25 U	**1630**	**421** J
Miscellaneous Semivolatiles (ug/L or ug/Kg, dry)				
N-Nitrosodiphenylamine	**0.41**	**1.5**	179 U	115 U
Dibenzofuran	**0.16**	**0.08** J	**53** J	**30** J
Carbazole	**0.18**	**0.18**	179 U	115 U
Dibenzothiophene	0.12 U	**0.05** J	179 U	115 U
3B-Coprostanol	0.62 U	0.62 U	**3370**	**2530**
Retene	0.25 U	0.25 U	**184**	**75** J

Table 6. Whitmarsh June 1998 Chemicals (continued)

Sample Type:	Seepage		Sediment	
Site Number:	1	2	1	2
Sample Number:	248005	248006	248007	248008
Polychlorinated Biphenyls (ug/L or ug/Kg, dry)				
PCB-1016	0.033 UJ	0.034 UJ	59 U	12 U
PCB-1221	0.033 UJ	0.034 UJ	59 U	12 U
PCB-1232	0.033 UJ	0.034 UJ	59 U	12 U
PCB-1242	**0.028** J	**0.011** J	59 U	12 U
PCB-1248	0.033 UJ	0.034 UJ	59 U	12 U
PCB-1254	0.033 UJ	0.034 UJ	59 U	12 U
PCB-1260	0.033 UJ	0.034 UJ	59 U	12 U
Organotins (ug/Kg, dry)				
Tributyltin chloride	- -	- -	**3.8** J	**3.6** J
Dibutyltin chloride	- -	- -	**3.9** J	**3.9** J
Monobutyltin chloride	- -	- -	**55** J	**44** J
Nitrogen-Containing Pesticides (ug/L or ug/Kg, dry)			nd	nd
Carbaryl	**4.5** J	**0.13** J	- -	- -
Organophosphorous Pesticides	nd	nd	nd	nd
Organochlorine Pesticides	nd	nd	nd	nd
Carbamate Pesticides				
Carbaryl	**5.8** J	**0.12** J	- -	- -
Herbicides	nd	nd	nd	nd

nd = None detected.

Table 6. Whitmarsh June 1998 Chemicals (continued)

Sample Type:	Seepage		Sediment	
Site Number:	1	2	1	2
Sample Number:	248005	248006	248007	248008
Polychlorinated Dioxins (ng/Kg, dry)				
2,3,7,8-TCDD	--	--	**0.23** NJ	**0.22** J
1,2,3,7,8-PeCDD	--	--	**1.2** J	**0.83** J
1,2,3,4,7,8-HxCDD	--	--	**2.0** J	**1.4** J
1,2,3,6,7,8-HxCDD	--	--	**6.0**	**4.9** J
1,2,3,7,8,9-HxCDD	--	--	**5.8**	**4.5** J
1,2,3,4,6,7,8-HpCDD	--	--	**75**	**68**
OCDD	--	--	**579**	**490**
Polychlorinated Furans (ng/Kg, dry)				
2,3,7,8-TCDF	--	--	**1.8**	**1.9**
1,2,3,7,8-PeCDF	--	--	**0.79** J	**0.52** J
2,3,4,7,8-PeCDF	--	--	**1.3** J	**0.78** J
1,2,3,4,7,8-HxCDF	--	--	**2.1** J	**1.5** J
1,2,3,6,7,8-HxCDF	--	--	**1.1** J	**0.73** J
2,3,4,6,7,8-HxCDF	--	--	**1.6** J	**1.2** J
1,2,3,7,8,9-HxCDF	--	--	0.2 U	0.2 U
1,2,3,4,6,7,8-HpCDF	--	--	**14**	**12**
1,2,3,4,7,8,9-HpCDF	--	--	**1.0** J	**0.89** J
OCDF	--	--	**35**	**30**

NJ = There is evidence that analyte may be present; associated numerical value is an estimate.

sites #1 and #2. The findings are reviewed below and compared to Skagit County's 1996 data for the same locations (Table 2) and other of the previously mentioned historical data. Chemicals of potential concern are identified.

Metals

Priority pollutant metals were not detectable in seepage from the landfill. The levels of chromium, copper, mercury, nickel, and zinc in the sediments were within SMS chemical criteria. There was a trace amount of beryllium, not an SMS chemical, in the sediments. These results are in good agreement with the metals data obtained by Skagit County in 1996.

The samples were also analyzed for a range of other trace elements. Results showed some elevations over concentrations typically seen in surface waters (Hem, 1970), but were generally unremarkable. As expected in landfill drainage, high concentrations of iron, 5,660 - 16,200 ug/L (parts per billion), occur in the seepage. Iron concentrations over 1,000 ug/L can be toxic to aquatic life (EPA, 1977). Iron levels in the sediments were also several times higher than normally encountered in Puget Sound (Ecology SEDQUAL Database)

With the exception of the single leachate sample collected by Fitzpatrick (1989), all available data indicate that priority pollutant metals are not a significant concern at Whitmarsh. Metals were analyzed in the follow-up sediment survey for a thorough comparison with the SMS chemical criteria. Iron, not a priority pollutant or SMS chemical, was also analyzed in light of its elevation in seepage and sediment.

Cyanide

Cyanide was not detectable in the water samples at or below 5 ug/L. Cyanide was not analyzed in sediment, but Skagit County was unable to detect cyanide in sediment or seepage from these sites. The Swinomish Tribe did not detect cyanide in a lagoon water sample collected near the landfill in 1997 (unpublished data).

Cyanide does not appear to be a chemical of concern.

Total Petroleum Hydrocarbons

The seepage contained hydrocarbons in the diesel range at concentrations of 470 - 850 ug/L (parts per billion). The patterns showed substantial weathering. Gasoline and lube oil range hydrocarbons were not detected in either seep.

No diesel or gasoline was detectable in the adjacent sediments. Site #2 in the southwest corner of the lagoon had hydrocarbons that eluted in the range of lubricating oil. This sample was analyzed in duplicate and quantitated against a lube oil standard. One of the two sub-samples had 190 mg/Kg, the other was below quantitation limits (160 mg/Kg).

A separate GC/FID hydrocarbon identification analysis was conducted on each of the Whitmarsh water and sediment samples. None displayed any pattern recognizable as a petroleum product (Carrell, 1998).

Previous analyses at Whitmarsh have not included a comparable analysis for petroleum. The USFWS (1994) analyzed aliphatic (straight and branched chain hydrocarbons) in a sediment sample collected from the inner lagoon in 1988 and concluded there was no evidence of petroleum contamination.

The detection of diesel in seepage and lube oil in the sediments are a concern and was reason for including a TPH analysis in the sediment survey.

Volatiles

Thirteen of the 81 volatile organic compounds analyzed were detected in Whitmarsh seepage. These included benzenes, chlorinated benzenes, toluene, xylenes, naphthalene, and ethylether. Concentrations were low, ranging from 0.1 - 2.5 ug/L. Benzene, chlorobenzene, toluene, and xylenes were also detected in seepage by Skagit County, but the concentrations tended to be slightly higher at 1 - 15 ug/L

Volatiles were not analyzed in Ecology sediment samples, but Skagit County found 8 -11 ug/Kg (parts per billion) of toluene and xylene. Toluene had also been detected at 51 ug/Kg in the site #1 sediments by Milham (1986). Additional volatiles only reported by Skagit County were 2-hexanone, methylene chloride, 2-butanone, 4-methylpentanone (site #1 only), and acetone. The highest concentrations were for the latter three compounds, 100 - 700 ug/Kg.

The concentrations of volatiles in Whitmarsh seepage would not be expected to be toxic. Water quality criteria for these types of compounds are orders of magnitude higher than the levels measured (Appendix D). Being rapidly lost to the atmosphere, they are unlikely to accumulate in sediments farther out in the lagoon. However, in view of the sheens and petroleum odors reported by the Swinomish Tribe as occurring over a wide area of the lagoon, a volatiles analysis was included in the sediment survey.

Semivolatiles

Of the 84 semivolatile compounds analyzed, 39 were detected. The compounds most commonly seen in both water and sediment samples were PAH and phenols. Four chlorinated compounds — 2-chloro-3-methylphenol, and 1,2-, 1,3-, and 1,4-dichlorobenzene — were detected in seepage but not sediment. As just noted, the presence of dichlorobenzenes was confirmed in the volatiles analysis. Additional semivolatiles identified in water and/or sediment included three phthalates — diethyl-, di-n-butyl-, and bis(2-ethylhexyl)phthalate — and six miscellaneous compounds — N-nitrosodiphenylamine, dibenzofuran, carbazole, dibenzothiophene, coprostanol, and retene.

Levels of semivolatiles in Whitmarsh seepage were low, 0.02 - 1.5 ug/L. Concentrations in this range are orders of magnitude below toxicity thresholds and well within available water quality criteria (Appendix D).

Sediment concentrations were in the range of 26 - 271 ug/Kg, with higher concentrations of phthalates, to 698 ug/Kg, and coprostanol, 2,530 - 3,370 ug/Kg. Both sites #1 and #2 had concentrations of 2-methylphenol and 2,4-dimethylphenol that exceeded the SMS Cleanup Screening Levels of 63 and 29 ug/Kg, respectively. A number of other compounds were elevated compared to reference areas in Puget Sound (EPA, 1991). These findings are evaluated in more detail later in this report.

With the exception of dichlorobenzenes, Skagit County reported the presence of the same types of semivolatile compounds in 1996, although fewer in number due to higher detection limits and a shorter list of analytes. Slightly higher concentrations were measured in seepage — naphthalene, 2-methylnaphthalene, 2,4-dimethylphenol, bis(2-ethylhexyl)phthalate, and N-nitrosodiphenylamine at 1 - 3 ug/L — and lower concentrations in sediment — 46 - 84 ug/Kg PAH and 100 - 440 ug/Kg bis(2-ethylhexyl)phthalate.

Phenols were not detected in Skagit County sediment samples at detection limits of 60 - 100 ug/Kg, sufficient to quantify the higher concentrations seen in Ecology samples. Whatever the reason for this discrepancy, the Ecology composite sample was collected from a much larger area (see Skagit County sample, Figure 6B) and is therefore more representative of sediment quality near the landfill. Ecology also failed to detect phenols in an earlier 1988 sediment sample collected near site #1 at detection limits of 20 - 40 ug/Kg (Johnson, 1989). Differences in sample location (along the north edge of the lagoon) and depth (the top 2-cm layer was analyzed rather than top 10-cm) may explain this result.

Phenols, PAH, phthalates, and other semivolatile compounds are clearly a concern at Whitmarsh, being detected in seepage and elevated in the sediments. Their analysis was extended to the sediment survey.

PCBs

PCB-1242 was detected in both discharges from the landfill at similar concentrations of 0.011 - 0.028 ug/L. These concentrations approach the state marine chronic water quality criterion of 0.03 ug/L (WAC 173-201A). PCBs were below detection limits, 12 - 59 ug/Kg, in the sediment samples.

The presence of PCBs at this site had not been reported previously. Inability to detect PCBs in the seepage is again likely due to analytical differences. Skagit County had comparable detection limits for sediment, 59 - 100 ug/Kg, but much higher limits of 1 ug/L for water.

PCBs are persistent and bioaccumulative SMS chemicals. Their detection in seepage is cause for concern and warranted analysis in the sediment survey.

Pesticides and Herbicides

Of the approximately 150 compounds analyzed, only carbaryl, an insecticide (Sevin), was detected and in seepage only. Results from two separate analytical methods gave almost identical results of 4.5 - 5.8 ug/L in the site #1 seep and 0.12 - 0.13 ug/L in the site #2 seep.

There are no state or EPA water quality criteria for carbaryl. A recommended maximum safe concentration of 0.02 ug/L has been proposed (NAS, 1973). Acute toxicity to sensitive marine species like crustaceans is reported to occur at concentrations as low as 5 ug/L (Buchanan et al., 1985). Carbaryl is unstable in seawater, with half-lives of several days (Aly and El-Dib, 1971). Dilution and degradation in the lagoon would be expected to rapidly reduce the concentrations in Whitmarsh seepage to non-toxic levels. Localized adverse effects on marine life could, however, be occurring along the base of the landfill.

Previous analyses for pesticides in Padilla Bay Lagoon by Skagit County and others have been limited to organochlorine insecticides (e.g., DDT, dieldrin, endosulfan). None of these compounds have been detected.

With the exception of carbaryl, pesticides and herbicides do not appear to be chemicals of concern. In view of carbaryl's low persistence, it was not analyzed for the sediment survey.

Organotins

Because of the proximity of shipyards and marinas to the landfill, the sediment samples were analyzed for the antifouling agent tributyltin. The levels seen at Whitmarsh are similar to background concentrations of 1 - 3 ug/Kg reported for Puget Sound sediments (PTI, 1988a). No previous analyses have been conducted for these compounds.

Organotins do not appear to be a concern.

Dioxins and Furans

The Texaco and Shell facilities on March Point are among five refineries in Washington that potentially have polychlorinated dioxins and -furans (PCDDs/PCDFs) in their waste streams. 2,3,7,8-TCDD (dioxin) has been detected at relatively high concentrations in wash water samples from Texaco (Yake et al., 1998). PCDDs and PCDFs were therefore analyzed in the sediment samples from the screening survey.

Both sites #1 and #2 had detectable concentrations of all but one of the seventeen 2,3,7,8-substituted PCDDs/PCDFs. Concentrations ranged from 0.2 ng/Kg 2,3,7,8-

TCDD to 579 ng/Kg OCDD (parts per trillion). No historical data are available for these compounds at Whitmarsh.

As described in more detail later in this report, the combined toxicity potential indicated by these concentrations, although not high, was of sufficient concern to warrant analysis in the sediment survey.

Compounds Tentatively Identified by GC/MS

A computer search was done to tentatively identify peaks of non-target compounds (TICs) seen in the volatiles and semivolatiles analyses. These are listed along with their estimated concentrations in Appendix E.

Most of the compounds tentatively identified in the seepage were additional types of substituted benzenes, PAH, and phenols. Concentrations were generally low and similar to related compounds specifically analyzed for, except for phenols and PAH in the site #1 seep. The total estimated concentration of the ten phenols tentatively identified here was 56 ug/L, high compared to 1.1 ug/L for target phenols. Concentrations of two groups of tentatively identified PAH, C1-flouranthenes/pyrenes and C2-dibenzothiophenes at 28 and 1,090 ug/L, respectively, were several orders of magnitude above target PAH.

1-Napthol, a degradation product of carbaryl, was tentatively identified in seep #1 at 4.8 ug/L. This finding is consistent with carbaryl's detection at 4.5 - 5.8 ug/L. Napthol is toxic to marine life, but only at substantial concentrations greater than 500 ug/L (Stewart et al., 1967).

An oxygenated compound, 2,4,6-cycloheptatriene -1-one (tropone), was identified at a relatively high concentration of 4.6 ug/L in seep #2. No toxicity data could be found on this chemical.

Most of the TICs in sediment are naturally occurring (e.g., phytol, a decomposition product of chlorophyll; cholestanol, from cholesterol; sitosterol and ergost-7-en-3B-ol, both plant sterols; and niacinamide or vitamin B3). A number of naturally occurring fatty acids (e.g., hexadecanioc acid) were also identified.

Although numerous compounds were identified in the TIC search, none appeared to warrant a specific analysis in the sediment survey. The sediment survey included a TIC search for the top 10 volatile and top 20 semivolatile unknowns.

Compounds Tentatively Identified by GC/AED

A screen for hetero-atoms containing nitrogen, sulfur, chlorine, or bromine was conducted as part of the pesticide and herbicide analysis. The only additional compound identified was diphenylamine, detected in both seeps at estimated concentrations of 0.32 - 1.0 ug/L.

Diphenylamine may be present as a degradation product of N-nitrosodiphenylamine, also detected in these samples, or from its use in rubber and plastics. No tentative identifications were made in the sediment samples.

In reporting results on the water samples, the analyst further observed but did not quantify "relatively large concentrations of nitrogen and sulfur compounds associated with rubber/plastic products" and "relatively large concentrations of phosphorous-containing plasticizers/fire retardants". These compounds, although not necessarily innocuous, are commonly seen in surface runoff samples, especially from urban areas (Olson, 1998).

A GC/AED screen was not included in the sediment survey.

Sediment Survey

Chemicals Detected

Results from the expanded sediment survey are summarized in Table 7. Data are included for the same chemicals analyzed in the sediments collected near Whitmarsh Landfill in June.

The sediments were predominantly silt and clay, except for site #5 at the east end of the lagoon which was mostly (78%) sand. Organic carbon content was elevated, 9.8% TOC, at site #3 on the north side of the inner lagoon and lowest, 0.9%, at the Samish Bay reference area. A range of 0.5 - 3% TOC is typical for Puget Sound (Michelsen and Bragdon-Cook, 1993).

Metal concentrations followed the pattern normally encountered in local marine sediments, i.e., iron > aluminum > zinc > chromium > nickel > copper > lead > arsenic > cadmium > mercury. For most metals, the highest concentrations were in the inner lagoon and exceeded concentrations at the Samish Bay reference area by factors of 2 to 3. The highest concentrations of lead, 50 mg/Kg, and beryllium, 3.0 mg/Kg, occurred outside the lagoon at site #6. Lead and beryllium levels at this location were 9 - 12 times higher than in the reference sediments. Cadmium was detectable only at inner lagoon site #3 and at a trace level of 0.48 mg/Kg. Antimony and thallium were below detection limits in all samples, but the accuracy of these results is questionable due to poor matrix spike recoveries (see Data Quality).

Sediments at site #3, approximately 200 yards east of the landfill, were black, viscous, and had a strong petroleum odor. Numerous, small (< 10 mm) tar balls could be seen in the grabs. TPH analysis confirmed high concentrations of petroleum. The hydrocarbons eluted in the range of diesel and lubricating oil, but were extremely weathered and did not match any common petroleum product. The results were

Table 7. Chemicals Detected in Padilla Bay Lagoon Sediment Samples in 1998
[Volatiles and semivolatiles show detected compounds only. Metals concentrations are in mg/Kg; organics are in ug/Kg, except ng/Kg for dioxins & furans; all on a dry weight basis.]

Location:	Inner Lagoon			Outer Lagoon		Outside Lagoon	Samish Bay
Site Number:	1	2	3	4	5	6	Ref. Area
Date:	11-Jun	11-Jun	7-Aug	7-Aug	7-Aug	7-Aug	7-Aug
Sample Number:	248007	248008	328004	328003	328002	328001	328000
Ancillary Parameters (%)							
Gravel	--	--	**6**	**4**	**0**	**1**	**0**
Sand	--	--	**21**	**6**	**78**	**24**	**64**
Silt	--	--	**50**	**59**	**15**	**53**	**22**
Clay	--	--	**23**	**31**	**7**	**22**	**13**
Total Organic Carbon	**3.8**	**3.6**	**9.8**	**3.7**	**1.3**	**2.7**	**0.9**
Priority Pollutant Metals							
Zinc	**98**	**93**	**111**	**80**	**48**	**68**	**42**
Chromium	**65**	**59**	**44**	**54**	**35**	**46**	**22**
Nickel	**51**	**42**	**40**	**46**	**31**	**41**	**26**
Copper	**44**	**39**	**35**	**38**	**21**	**33**	**12**
Lead	**13**	**13**	**34**	**12**	**6.6**	**50**	**5.8**
Arsenic	**11**	**12**	**9.8**	**11**	**6.7**	**8.9**	**4.8**
Beryllium	**0.39**	**0.40**	**0.30**	**0.38**	**0.23**	**3.0**	**0.25**
Silver	0.4 U	0.4 U	**0.70** J	**0.54** J	**0.47** J	**0.56** J	0.4 U
Selenium	**0.50**	**0.42**	**0.40**	**0.35**	**0.33**	0.3 U	0.3 U
Cadmium	0.5 U	0.5 U	**0.48**	0.4 U	0.4 U	0.4 U	0.4 U
Mercury	**0.082**	**0.076**	**0.095** J	**0.081** J	**0.047** J	**0.078** J	**0.048** J
Antimony	3 UJ	3 UJ	3 UJ	3 UJ	3 UJ	3 UJ	3 UJ
Thallium	0.3 U	0.3 U	0.3 UJ	0.3 UJ	0.3 UJ	0.3 UJ	0.3 UJ
Other Metals							
Iron	**47000**	**47500**	**28300**	**26400**	**19500**	**25200**	**15100**
Aluminum	**19900**	**19200**	**14200**	**17600**	**10800**	**14100**	**8930**

Note: Detections indicated in **bold**.
- - = Not analyzed.
U = Not detected at or above reported value (i.e., less than)
J = The analyte was positively identified; associated numerical value is an estimated.
UJ = The analyte was not detected at or above the reported estimated result.

Table 7. Chemicals in Lagoon Sediments (continued)

Location:	Inner Lagoon			Outer Lagoon		Outside Lagoon	Samish Bay
Site Number:	1	2	3	4	5	6	Ref. Area
Date:	11-Jun	11-Jun	7-Aug	7-Aug	7-Aug	7-Aug	7-Aug
Sample Number:	248007	248008	328004	328003	328002	328001	328000
Total Petroleum Hydrocarbons (mg/L or mg/Kg, dry)							
#2 Diesel	70 U	44 U	**5300** J	56 U	25 U	73 U	31 U
Lube Oil	180 U	**190**	**4000** J	140 U	63 U	180 U	77 U
Volatile Organic Compounds							
Carbon disulfide	--	--	**16** J	**5.6** J	**2.4** J	**7.8** J	5 U
2-Butanone	--	--	**31**	7.7 U	6 U	**28** U	5 U
Benzene	--	--	**10**	3.8 U	3 U	3.3 U	2.5 U
Toluene	--	--	**160**	**61**	**0.61** J	3.3 U	**1.1** J
Ethylbenzene	--	--	**260** J	3.8 U	3 U	3.3 U	2.5 U
m & p-Xylene	--	--	**2070**	7.7 U	6 U	6.7 U	5 U
o-Xylene	--	--	**350** J	3.8 U	3 U	3.3 U	2.5 U
Isopropylbenzene	--	--	**34**	3.8 U	3 U	3.3 U	2.5 U
n-Propylbenzene	--	--	**223** J	3.8 U	3 U	3.3	2.5 U
1,3,5-Trimethylbenzene	--	--	**130** J	3.8 U	3 U	3.3	2.5 U
1,2,4-Trimethylbenzene	--	--	**506**	3.8 U	3 U	3.3	2.5 U
Sec-Butylbenzene	--	--	**46**	3.8 U	3 U	3.3	2.5 U
p-Isopropyltoluene	--	--	**78**	3.8 U	3 U	3.3	2.5 U
n-Butylbenzene	--	--	**123**	3.8 U	3 U	3.3	2.5 U
Naphthalene	--	--	**131**	3.8 U	3 U	3.3 U	2.5 U
Low Molecular Weight Polyaromatic Hydrocarbons							
Naphthalene	**66** J	**44** J	**386**	**8.7** J	**11** J	**7.4** J	**8.4** J
1-Methylnaphthalene	**50** J	**32** J	**986**	**6.6** J	78 U	**4.6** J	**7.1** J
2-Methylnaphthalene	**87** J	**60** J	**1330**	**11** J	**9.5** J	**6.7** J	**8.6** J
2,6-Dimethylnaphthalene	**352**	**219**	**1120**	**14** J	**4.5** J	**29** J	**6.1** J
1,6,7-Trimethylnaphthalene	179 U	**37** J	**515**	61 U	78 U	52 U	**5.7** J
Acenaphthene	**35** J	115 U	**144** J	**4.2** J	**4.0** J	**3.1** J	**4.4** J
Fluorene	**52** J	**29** J	**140** J	**7.7** J	**5.8** J	**7.1** J	**14** J
Acenaphthylene	179 U	115 U	254 U	**6.4** J	**2.8** J	**3.9** J	**7.1** J
Phenanthrene	**198**	**112** J	**390**	**30** J	**18** J	**40** J	**101**
1-Methylphenanthrene	**287**	**234**	254 U	61 U	78 U	52 U	**65**
2-Methylphenanthrene	**61** J	**26** J	254 U	61 U	78 U	52 U	**53**
Anthracene	**64** J	**27** J	254 U	**9.1** J	**6.1** J	**11** J	**25** J
Total LPAH	**1252**	**820**	**5011**	**98**	**62**	**113**	**305**

Table 7. Chemicals in Lagoon Sediments (continued)

Location:	Inner Lagoon			Outer Lagoon		Outside Lagoon	Samish Bay
Site Number:	1	2	3	4	5	6	Ref Area
Date:	11-Jun	11-Jun	7-Aug	7-Aug	7-Aug	7-Aug	7-Aug
Sample Number:	248007	248008	328004	328003	328002	328001	328000
High Molecular Weight Polyaromatic Hydrocarbons							
Fluoranthene	**332**	**161**	254 U	**53** J	**38** J	**119**	**125**
Pyrene	**311**	**146**	254 U	**51** J	**33**	**94**	**110**
Benzo(a)anthracene	**123** J	**66** J	254 U	61 U	78 U	**32** J	**45**
Chrysene	**240**	**112** J	**151** J	121 U	**22** J	**49** J	**40**
Benzo(b)fluoranthene	**283**	**138**	1270 U	**45** J	**40** J	**52** J	**54** J
Benzo(k)fluoranthene	**79** J	**40** J	254 U	**14** J	**8.3** J	**14** J	**17** J
Benzo(e)pyrene	**127** J	**72** J	254 U	**16** J	**13** J	**20** J	**20** J
Benzo(a)pyrene	**103** J	**35** J	254 U	**17** J	**13** J	**18** J	**43**
Perylene	**263**	**123**	254 U	**46** J	**38** J	**42** J	**32** J
Indeno(1,2,3-cd)pyrene	**229** J	576 U	1270 U	**17** J	**9.7** J	**11** J	**27** J
Dibenzo(a,h,)anthracene	359 U	231 U	254 U	61 U	78 U	**28** J	**22** J
Benzo(g,h,i)perylene	**192**	**116**	1270 U	**12** J	392 U	**6.9** J	**25** J
Total HPAH	**2282**	**1009**	**151**	**271**	**215**	**486**	**560**
Phenols							
Phenol	**178** J	**271**	**820**	61 U	78 U	52 U	35 U
2-Methylphenol	**180**	**121**	**1740**	61 U	78 U	52 U	35 U
4-Methylphenol	**545**	**238**	**7950**	**16** J	**44** J	**17** J	**5.9** J
2,4-Dimethylphenol	**288**	**118**	**5580**	161 U	78 U	52 U	35 U
4-Nitrophenol	897 U	576 U	**570** J	605 U	784 U	516 U	349 U
Phthalate Esters							
Bis(2-ethylhexyl)phthalate	**1630**	**421** J	771 U	**119** J	157 U	**63** J	70 U
Di-n-butylphthalate	**1380**	**698**	254 U	61 U	83 U	52 U	71 U
Butylbenzylphthalate	897 U	576 U	**2970** J	303 U	392 U	258 U	174 U
Diethylphthalate	**25** J	576 U	1270 U	303 U	392 U	258 U	174 U

Table 7. Chemicals in Lagoon Sediments (continued)

Location:	Inner Lagoon			Outer Lagoon		Outside Lagoon	Samish Bay
Site Number:	1	2	3	4	5	6	Ref. Area
Date:	11-Jun	11-Jun	7-Aug	7-Aug	7-Aug	7-Aug	7-Aug
Sample Number:	248007	248008	328004	328003	328002	328001	328000
Miscellaneous Semivolatiles							
3B-Coprostanol	**3370**	**2530**	5090 U	**731** J	**432** J	**297** J	**188** J
Dibenzofuran	**53** J	**30** J	**81** J	**8.1** J	**5.9** J	**6.2** J	**6.4** J
Retene	**184**	**75** J	254 U	**22** J	**16** J	**18** J	**13** J
Dibenzothiophene	179 U	115 U	**145** J	61 U	78 U	52 U	35 U
Carbazole	179 U	115 U	254 U	61 U	78 U	52 U	**9.8** J
1,1'-Biphenyl	179 U	115 U	254 U	61 U	78 U	52 U	**6.5** J
Bis(2-chloroethyl)ether	359 U	231 U	254 U	61 U	78 U	**2.5** J	35 U
Polychlorinated Biphenyls							
PCB-1016	59 U	12 U	1.6 UJ	1.3 U	1.3 U	1.6 U	1.1 U
PCB-1221	59 U	12 U	1.6 UJ	1.3 U	1.3 U	1.6 U	1.1 U
PCB-1232	59 U	12 U	22 UJ	1.3 U	1.3 U	1.6 U	1.1 U
PCB-1242	59 U	12 U	2100 UJ	1.3 U	1.3 U	1.6 U	1.1 U
PCB-1248	59 U	12 U	63 UJ	1.3 U	1.3 U	1.6 U	1.1 U
PCB-1254	59 U	12 U	490 UJ	1.3 U	1.3 U	1.6 U	1.1 U
PCB-1260	59 U	12 U	7.9 UJ	1.3 U	1.3 U	1.6 U	1.1 U
Polychlorinated Dioxins							
2,3,7,8-TCDD	**0.23** NJ	**0.22** J	0.29 U	1.4 U	0.12 U	0.13 U	0.2 U
1,2,3,7,8-PeCDD	**1.2** J	**0.83** J	**0.46** J	**2.0** J	0.97 U	0.25 U	0.19 U
1,2,3,4,7,8-HxCDD	**2.0** J	**1.4** J	**0.91** J	**2.6** J	**0.26** J	0.22 U	0.47 U
1,2,3,6,7,8-HxCDD	**6.0**	**4.9** J	**2.2** J	**8.1**	**0.38** J	0.38 U	0.36 U
1,2,3,7,8,9-HxCDD	**5.8**	**4.5** J	**1.2** J	**4.0** J	0.29 U	0.32 U	0.2 U
1,2,3,4,6,7,8-HpCDD	**75**	**68**	**36**	**120**	**7.6**	1.4 U	**2.8** J
OCDD	**579**	**490**	**270**	**670**	**77**	**12**	**18** J
Polychlorinated Furans							
2,3,7,8-TCDF	**1.8**	**1.9**	**0.86** J	**0.83** J	0.25 U	0.2 U	0.3 U
1,2,3,7,8-PeCDF	**0.79** J	**0.52** J	1.4 U	**1.1** J	0.49 U	0.1 U	0.15 U
2,3,4,7,8-PeCDF	**1.3** J	**0.78** J	**0.36** J	2.3 U	0.15 U	0.14 U	0.22 U
1,2,3,4,7,8-HxCDF	**2.1** J	**1.5** J	0.43 U	**3.6** J	0.62 U	0.17 U	**0.36** J*
1,2,3,6,7,8-HxCDF	**1.1** J	**0.73** J	**0.61** J	**2.3** J	0.24 U	0.1 U	**0.22** J

NJ = There is evidence that analyte may be present; associated numerical value is an estimate.

*Not detected in a duplicate analysis of this sample.

Table 7. Chemicals in Lagoon Sediments (continued)

Location:	Inner Lagoon			Outer Lagoon		Outside Lagoon	Samish Bay
Site Number:	1	2	3	4	5	6	Ref Area
Date:	11-Jun	11-Jun	7-Aug	7-Aug	7-Aug	7-Aug	7-Aug
Sample Number:	248007	248008	328004	328003	328002	328001	328000
Polychlorinated Furans (continued)							
2,3,4,6,7,8-HxCDF	**1.6** J	**1.2** J	**0.89** J	**3.7** J	0.43 U	0.3 U	**0.40** J*
1,2,3,7,8,9-HxCDF	0.2 U	0.2 U	0.21 U	0.93 U	0.42 U	0.2 U	0.18 U
1,2,3,4,6,7,8-HpCDF	**14.0**	**11.9**	20 U	**24**	7.3 U	1 U	**0.55** J
1,2,3,4,7,8,9-HpCDF	**1.0** J	**0.89** J	0.71 U	**2.0** J	0.78 U	0.29 U	0.24 U
OCDF	**35**	**30**	**12**	**38**	**4.5** J	0.7 U	**0.91** J*
TEQ**	**5.1**	**4.0**	**1.7**	**5.7**	**0.22**	**0.012**	**0.15**

*Not detected in a duplicate analysis of this sample.

**2,3,7,8-TCDD Equivalence (summed for all dioxin and furan congeners) calculated against #2 diesel and composite motor oil standards. Concentrations were estimated to be 5,300 ug/Kg as diesel and 4,000 ug/Kg as lube oil

No petroleum was detectable in the outer lagoon, outside the lagoon, or at the reference area. As already noted, sediments analyzed from the base of Whitmarsh Landfill in June had a small amount of lube oil detected in one sample, 190 ug/Kg at site #2.
Almost all of the organic compounds that had been identified in screening the Whitmarsh sediments were also detected at least at one site farther out in the lagoon. Three compounds — di-n-butylphthalate, diethylphthalate, and 2,3,7,8-TCDD — were only detected near the landfill. Four of the volatiles that Skagit County had reported — 2-hexanone, methylene chloride, 4-methylpentanone, and acetone — were also not detected elsewhere in the lagoon.

Fifteen volatile organics were detected at site #3, ranging from benzene (10 ug/Kg) to xylenes (2,420 ug/Kg). All of these except 2-butanone are components of petroleum. 2-Butanone (methylethyl ketone) is a common solvent, also produced in exhaust from gasoline engines. Outer lagoon sediments showed little evidence of contamination by volatile compounds. 2-Butanone was detected outside the lagoon at a concentration of 28 ug/Kg, comparable to 31 ug/Kg at site #3. The only volatile detectable in the reference area sediments was 1.1 ug/Kg toluene.

The most numerous and widely distributed compounds were PAH. Concentrations of low molecular weight PAH (2 - 3 ring compounds) at site #3 were one to two orders of magnitude higher than elsewhere in the lagoon. Methylnaphthalenes were the primary constituents. High molecular weight PAH (4 - 6 rings) were generally not detectable at site #3. For both groups of compounds, outer lagoon concentrations were comparable to or not substantially above the reference sediments. Total LPAH and HPAH in sediments near the landfill were two to four times higher than reference

PAH compounds are found in fossil fuels or formed during their combustion. Elevated concentrations of LPAH are considered to indicate petroleum, while high concentrations of HPAH are generally attributed to combustion of fossil fuels (Prahl and Carpenter, 1984; Tetra Tech, 1985). Petroleum sources have a higher percentage of alkly substituted LPAH (as seen for naphthalenes at site #3) compared to the parent compounds (Lake et al., 1979).

High concentrations, 820 - 7,950 ug/Kg, of four phenolic compounds — phenol, 2-methylphenol, 4-methylphenol, and 2,4-dimethylphenol — also occurred at site #3. The same compounds had been detected in sediments near the landfill at 118 - 545 ug/Kg. Only 4-methylphenol was detectable in the outer lagoon; concentrations were 16 - 44 ug/Kg. The reference sediment had 5.9 ug/Kg of 4-methylphenol. These are components of coal tars and, to a lesser extent, petroleum, but have a variety of other sources. In Puget Sound, 4-methylphenol is often found elevated in areas with wood waste.

4-Nitrophenol was detected at site #3 at 570 ug/Kg, but not elsewhere in the lagoon. This compound is an intermediate in organic synthesis, a fungicide for leather, and degradation product of the insecticide parathion. There are no known natural sources of 4-nitrophenol (ATSDR, 1992) and it is rarely reported in Puget Sound sediments. Perhaps coincidentally, it was recently detected at 46 ug/Kg in nearby Fidalgo Bay, adjacent to the same BNRR tracks than run by site #3 (Johnson, 1997).

Phthalates were detected primarily in the inner lagoon. Like PAH and phenols, these are common environmental contaminants. Their chief use is as plasticizers to give flexibility to synthetic polymers (e.g., PVC). The highest concentrations were for bis(2-ethylhexyl)phthalate and di-n-butylphthalate at site #1 — 1,630 and 1,380 ug/Kg, respectively, and butlybenzylphthalate at site #3 — 2,970 ug/Kg. A trace of diethylphthalate was also found at site #1. No phthalates were detectable in the reference sediments.

Four additional miscellaneous semivolatiles were detected in the lagoon: coprostanol, dibenzothiophene, dibenzofuran, and retene. Coprostanol is an environmentally persistent steroid formed in the digestive tract of mammals (Shigenaka and Price, 1988). Its presence indicates inputs of human and/or animal fecal matter. Concentrations of 2,530 - 3,370 ug/Kg were measured at sites #1 and #2 near the landfill, with much lower concentrations of 297 - 731 ug/Kg in the outer lagoon. The reference area had 188 ug/Kg. Coprostanol concentrations up to 2,800 ug/Kg have been measured in the sediments of Commencement Bay (Tetra Tech, 1985).

Dibenzothiophene, dibenzofuran, and retene are variously associated with coal, tars, and petroleum. The highest concentrations, 30 - 184 ug/Kg, also occurred in the inner lagoon.

Although PCB-1242 had been found in Whitmarsh seepage, none of the sediment samples had detectable concentrations of this or other PCB mixtures. The low detection limits of 1.1 - 1.6 ug/Kg achieved in the August sediment samples are appropriate for analyzing background levels of PCBs. Interferences raised the detection limits for PCB-1242 in the site #3 sample to 2,100 ug/Kg. PCBs once had wide use as insulating fluids, plasticizers, in inks, and as heat transfer and hydraulic fluids. PCB manufacture was banned in 1979.

Compared to the sediments near Whitmarsh, fewer and lower concentrations of PCDDs and PCDFs were detected farther out in the lagoon. 2,3,7,8-TCDD was not detectable at sites #3 - #6 or in the reference area. Dioxins and furans are unintended byproducts from combustion of organic matter in the presence of chloride, incineration of municipal and hospital wastes, and chlorine bleaching of wood pulp. They are contaminants in some chlorinated organic products such as pentachlorophenol.

The toxicity of PCDD/PCDF mixtures in environmental samples can be evaluated using a set of toxicity equivalency factors (TEFs) to convert concentrations of individual compounds to equivalent concentrations of 2,3,7,8-TCDD. An example calculation is shown in Appendix F. The combined toxicity estimate is referred to as the 2,3,7,8-TCDD equivalence or TEQ. TEQs in Padilla Bay Lagoon sediments (in ng/Kg, parts per trillion) fell into three categories: 5.6 - 1.6 (sites #1 - #4), 0.22 - 0.15 (site #5 and reference area), and 0.012 (site #6).

Results of the TIC search on the August sediment samples are in Appendix E. The primary finding of interest was the presence of additional substituted benzenes and phenols at site #3 in substantial concentrations estimated at 12,600 - 104,000 ug/Kg.

Toxicity Tests

Results of the sediment bioassays are summarized in Table 8. Laboratory controls and the Samish Bay reference sediment met SMS performance standards for the amphipod test (mortality less than 10% and 25%, respectively); echinoderm larvae test (control less than 50% combined abnormality and mortality); and juvenile polychaete test (less than 10% mortality in the control and reference biomass at least 80% of control biomass).

No toxicity was seen in the reference sediments. As expected from the high levels of petroleum and phenols, the sediments at site #3 were extremely toxic across all three tests, causing zero survival in each instance.

Outer lagoon sites #4 and #5, and site #6 north of the lagoon showed no acute toxicity in the amphipod or polychaete bioassays. There was slight but significantly less growth of polychaetes for sites #5 and #6, suggesting a low level of chronic toxicity to this species.

The sea urchin bioassay showed significant abnormal development for all three of the above areas (t-test, $p \leq 0.05$). The mean survivorship of normal larvae was similar at each site, 32 - 36%. Percent normals averaged 77% for the reference sediment and 82% for the control. The chemical data furnish no clues as to the reason for toxicity.

Bioassays were not conducted on the sediment samples collected near Whitmarsh in June. As noted earlier in this report, previous tests, using the amphipod *R. abronius*, have shown significant toxicity in this part of the lagoon (Bulthuis & Shaw, 1992; Wiggins, 1992).

Sediment Management Standards

Results of the sediment survey are compared in Table 9 to Ecology's SMS chemical criteria. Chemicals meeting Sediment Quality Standards (SQS) are not expected to cause adverse effects on biological resources. The Cleanup Screening Level (CSL) is the upper limit of allowable minor adverse effects on biological resources.

There are currently no numerical SMS human health criteria. A narrative standard states that sediment quality shall result in ... *no significant health risk to humans* (WAC 173-204-320).

Table 8. Results of Bioassays on Sediments Collected from Padilla Bay Lagoon and Vicinity on August 7, 1998
[Mean of 5 replicates each; +/- 1 standard deviation]

Location	Site No.	Sample No.	Amphipod - 10 day		Polychaete - 20 day		Sea Urchin - 4 day
			% Survival	% Emergence	% Survival	Biomass (mg)	% Normal
Laboratory Control	- -	- -	90 +/- 4	10 +/- 5	100 +/- 0	11.3 +/- 1.3	82 +/- 7
Samish Bay	Ref. Area	32800	95 +/- 6	12 +/- 9	100 +/- 0	10.9 +/- 1.0	77 +/- 13
Outside Lagoon Entrance	6	328001	91 +/- 10	12 +/- 5	100 +/- 0	**9.3 +/- 1.3***	**32 +/- 15***
Outer Lagoon, E. End	5	328002	95 +/- 6	12 +/- 5	88 +/- 27	**9.6 +/- 0.7***	**35 +/- 18***
Outer Lagoon, W. End	4	328003	83 +/- 20	5 +/- 4	96 +/- 9	11.5 +/- 1.1	**36 +/- 19***
Inner Lagoon, N. Side	3	328004	**0 +/- 0***	**73 +/- 5***	**0 +/- 0***	NA	**0 +/- 0***

*Significantly less than reference area (t test, $p<.05$)
NA = Not applicable due to zero percent survival

Table 9. Padilla Bay Lagoon Sediment Chemistry Compared to Ecology Marine Sediment Management Standards

Location:	Inner Lagoon			Outer Lagoon		Outside Lagoon	Samish Bay	Sediment Quality Standard	Cleanup Screening Level
Site Number:	1	2	3	4	5	6	Ref. Area		
Metals (mg/Kg, dry weight)									
Arsenic	**11**	**12**	**9.8**	**11**	**6.7**	**8.9**	**4.8**	57	93
Cadmium	0.5 U	0.5 U	**0.48**	0.4 U	0.4 U	0.4 U	0.4 U	5.1	6.7
Chromium	**65**	**59**	**44**	**54**	**35**	**46**	**22**	260	270
Copper	**44**	**39**	**35**	**38**	**21**	**33**	**12**	390	390
Lead	**13**	**13**	**34**	**12**	**6.6**	**50**	**5.8**	450	530
Mercury	**0.082**	**0.076**	**0.95**	**0.081**	**0.047**	**0.078**	**0.048**	0.41	0.59
Silver	0.4 U	0.4 U	**0.70**	**0.54**	**0.47**	**0.56**	0.4 U	6.1	6.1
Zinc	**98**	**93**	**111**	**80**	**48**	**68**	**42**	410	960
Nonionizable Organic Compounds (mg/Kg TOC)									
Polyaromatic Hydrocarbons									
Total LPAH[a]	**11**	**5.9**	**11**	**1.8**	**3.7**	**2.7**	**18**	370	780
Naphthalene	**1.7**	**1.2**	**3.9**	**0.2**	**0.8**	**0.3**	**0.9**	99	170
Acenaphthylene	4.7 U	3.2 U	2.6 U	**0.2**	**0.2**	**0.1**	**0.8**	66	66
Acenaphthene	**0.9**	3.2 U	**1.5**	**0.1**	**0.3**	**0.1**	**0.5**	16	57
Fluorene	**1.4**	**0.8**	**1.4**	**0.2**	**0.4**	**0.3**	**1.6**	23	79
Phenanthrene	**5.2**	**3.1**	**4.0**	**0.8**	**1.4**	**1.5**	**11**	100	480
Anthracene	**1.7**	**0.8**	2.6 U	**0.2**	**0.5**	**0.4**	**2.8**	220	1200
2-Methylnaphthalene	**2.3**	**1.7**	14	**0.3**	**0.7**	**0.2**	**1.0**	38	64

Note: Detections indicated in **bold**

U = Not detected at or above reported value (i.e. less than)

[a]naphthalene+acenaphthylene+acenaphthene+fluorene+phenanthrene+anthracene

Table 9. Comparison to Sediment Management Standards (continued)

Location:	Inner Lagoon			Outer Lagoon		Outside Lagoon	Samish Bay	Sediment Quality Standard	Cleanup Screening Level
Site Number:	1	2	3	4	5	6	Ref. Area		
Nonionizable Organic Compounds (mg/Kg TOC)									
Polyaromatic Hydrocarbons									
Total HPAH[b]	**53**	**25**	**1.5**	**6.1**	**14**	**16**	**56**	960	5300
Fluoranthene	**8.7**	**4.5**	2.6 U	**1.4**	**2.9**	**4.4**	**14**	160	1200
Pyrene	**8.2**	**4.1**	2.6 U	**1.4**	**2.5**	**3.5**	**12**	1000	1400
Benzo[a]anthracene	**3.2**	**1.8**	2.6 U	1.6 U	6.0 U	**1.2**	**5.0**	110	270
Chrysene	**6.3**	**3.1**	**1.5**	3.3 U	**1.7**	**1.8**	**4.4**	110	460
Tot. Benzofluoranthenes	**9.5**	**4.9**	16 U	**1.6**	**3.7**	**2.4**	**7.9**	230	450
Benzo[a]pyrene	**2.7**	**1.0**	2.6 U	**0.5**	**1.0**	**0.7**	**4.8**	99	210
Indeno[1,2,3-c,d]pyrene	**6.0**	16 U	13 U	**0.5**	**0.7**	**0.4**	**3.0**	34	88
Dibenzo[a,h]anthracene	9.4 U	6.4 U	2.6 U	1.6 U	6.0 U	**1.0**	**2.4**	12	33
Benzo[g,h,i]perylene	**5.1**	**3.2**	13 U	**0.3**	30 U	**0.3**	**2.8**	31	78
Chlorinated Benzenes									
1,2-Dichlorobenzene	4.7 U	3.2 U	2.6 U	1.6 U	6.0 U	1.9 U	3.9 U	2.3	2.3
1,4-Dichlorobenzene	9.4 U	6.4 U	2.6 U	1.6 U	6.0 U	1.9 U	3.9 U	3.1	9
1,2,4-Trichlorobenzene	4.7 U	3.2 U	2.6 U	1.6 U	6.0 U	1.9 U	3.9 U	0.81	1.8
Hexachlorobenzene	4.7 U	3.2 U	2.6 U	1.6 U	6.0 U	1.9 U	3.9 U	0.38	2.3

[b]fluoranthene+pyrene+benzo[a]anthracene+chrysene+total benzofluoranthenes+benzo[a]pyrene indeno[1,2,3-c,d]pyrene+dibenzo[a,h]anthracene+benzo[g,h,i]perylene

Table 9. Comparison to Sediment Management Standards (continued)

Location:	Inner Lagoon			Outer Lagoon		Outside Lagoon	Samish Bay	Sediment Quality Standard	Cleanup Screening Level
Site Number:	1	2	3	4	5	6	Ref. Area		
Nonionizable Organic Compounds (mg/Kg TOC)									
Phthalate Esters									
Dimethyl phthalate	4.7 U	3.2 U	2.6 U	1.6 U	6.0 U	1.9 U	3.9 U	53	53
Diethyl phthalate	**0.7**	16 U	13 U	8.2 U	30 U	9.6 U	19 U	61	110
Di-N-butyl phthalate	**36**	**19**	2.6 U	1.6 U	6.4 U	1.9 U	7.9 U	220	1700
Butylbenzyl phthalate	24 U	16 U	**30**	8.2 U	30 U	9.6 U	19 U	4.9	64
Bis(2-ethylhexyl)phthalate	**43**	**12**	7.9 U	**3.2**	12 U	**2.3**	7.8 U	47	78
Di-N-Octyl phthalate	9.4 U	6.4 U	13 U	8.2 U	30 U	9.6 U	19 U	58	4500
Miscellaneous									
Dibenzofuran	**1.4**	**0.8**	**0.8**	**0.2**	**0.5**	**0.2**	**0.7**	15	58
Hexachlorobutadiene	4.7 U	3.2 U	2.6 U	1.6 U	6.0 U	1.9 U	3.9 U	3.9	6.2
N-Nitrosodiphenylamine	4.7 U	3.2 U	2.6 U	1.6 U	6.0 U	1.9 U	3.9 U	11	11
Poychlorinated Biphenyls									
Total PCBs	11 U	2.3 U	27 U	0.2 U	0.7 U	0.4 U	0.9 U	12	65
Ionizable Organic Compounds (ug/Kg, dry weight)									
Phenol	**178**	**271**	**820**	61 U	78 U	52 U	35 U	420	1200
2-Methylphenol	**180**	**121**	**1740**	61 U	78 U	52 U	35 U	63	63
4-Methylphenol	**545**	**238**	**7950**	**16**	**44**	**17**	**5.9**	670	670
2,4-Dimethylphenol	**288**	**118**	**5580**	161 U	78 U	52 U	35 U	29	29
Pentachlorophenol	897 U	576 U	1270 U	303 U	392 U	258 U	174 U	360	690
Benzyl alcohol	179 U	115 U	254 U	61 U	78 U	52 U	35 U	57	73
Benzoic acid	REJ	REJ	REJ	REJ	REJ	REJ	REJ	650	650

REJ = Data rejected [ ] = Exceeds SQS [shaded] = Exceeds CSL

For comparison to the standards, concentrations of non-ionizable organic compounds (e.g., PAH, phthalates, and PCBs) are normalized to the organic carbon content of the sample in question (dry weight concentration divided by the decimal fraction representing percent TOC). For a given chemical concentration, sediment toxicity typically varies inversely with TOC. As directed in the standards, only detected concentrations were used to calculate total LPAH and total HPAH, and methylnaphthalenes were not included. For individual undetected compounds, the detection limit is used in normalizing.

Thirty-five of the 47 chemical parameters in the standards were quantified in Padilla Bay Lagoon. SMS chemicals not detected in sediments were 1,2-dichlorobenzene, 1,4-dichlorobenzene, 1,2,4-trichlorobenzene, hexachlorobenzene, dimethylphthalate, di-N-octylphthalate, hexachlorobutadiene, N-nitrosodiphenylamine, PCBs, pentachlorophenol, and benzyl alcohol. As noted in the discussion on data quality, no useful data were obtained for one of the SMS chemicals, benzoic acid. In some instances, the detection limits for chlorinated benzenes and hexachlorobutadiene may not have been sufficiently low for comparison to the SMS.

As highlighted in Table 9, sediments in inner Padilla Bay Lagoon exceeded the CSLs for 2-methylphenol and 2,4-dimethylphenol at all three sampling sites. Site #3 also exceeded the CSL for 4-methylphenol. The SQS for phenol, but not the CSL, was exceeded at site #3. Site #1 approached but did not exceed the SQS for bis(2-ethylhexyl)phthalate. Table 10 lists the sites not meeting standards and the extent of the exceedances.

Results of sediment bioassays exceed CSLs when any two of the three required tests exceed the biological effects criteria or when any one of the tests exceeds specific toxicity levels (see WAC 173-204 for details). Inner lagoon site #3 obviously exceeds the CSL for biological effects, since all test organisms died. Sediments from sites #4, #5, and #6 also exceed the CSL for the echinoderm larvae test. This CSL is exceeded when The test sediment has a mean survivorship of normal larvae that is less (statistically significant, t test, $p \leq 0.1$) than the mean normal survivorship in the reference sediment, and the test sediment mean normal survivorship is less than 70% of the mean normal survivorship in the reference sediment. Sites #5 and #6 also exceed CSLs due to the fact that each had two bioassays, polychaete and echinoderm, exceeding the biological effects criteria.

Figure 7 illustrates where CSLs for chemical criteria and biological effects were exceeded in Padilla Bay Lagoon.

When CSLs are exceeded, a determination is made if "station clusters of potential concern" exist. Station clusters are defined as a number of stations (minimum of three) that are spatially and chemically similar. A station cluster is of potential concern when the average of the three highest concentrations for any chemical or biological effect exceeds the CSL (Ecology, 1996). Such sites are evaluated by Ecology's Sediment Management Unit for inclusion on the Contaminated Sediment Site List and, if listed, are

Table 10. Chemicals Exceeding or Approaching Sediment Standards in Padilla Bay Lagoon
[Concentrations in ug/Kg, dry; except BEHP in mg/Kg TOC]

Chemical Parameter	Site	Concentration	Standard Exceeded / Factor
Phenol	#3	820	MC / 2.0
2-Methylphenol	#1	180	CSL / 2.8
"	#2	121	CSL / 1.9
"	#3	1740	CSL / 28
4-Methylphenol	#3	7950	CSL / 12
2,4-Dimethylphenol	#1	288	CSL / 10
"	#2	118	CSL / 4.1
"	#3	5580	CSL / 192
Bis(2-ethylhexyl)phthalate	#1	43	MC / 0.9

MC = Marine Criteria
CSL = Cleanup Screening Level

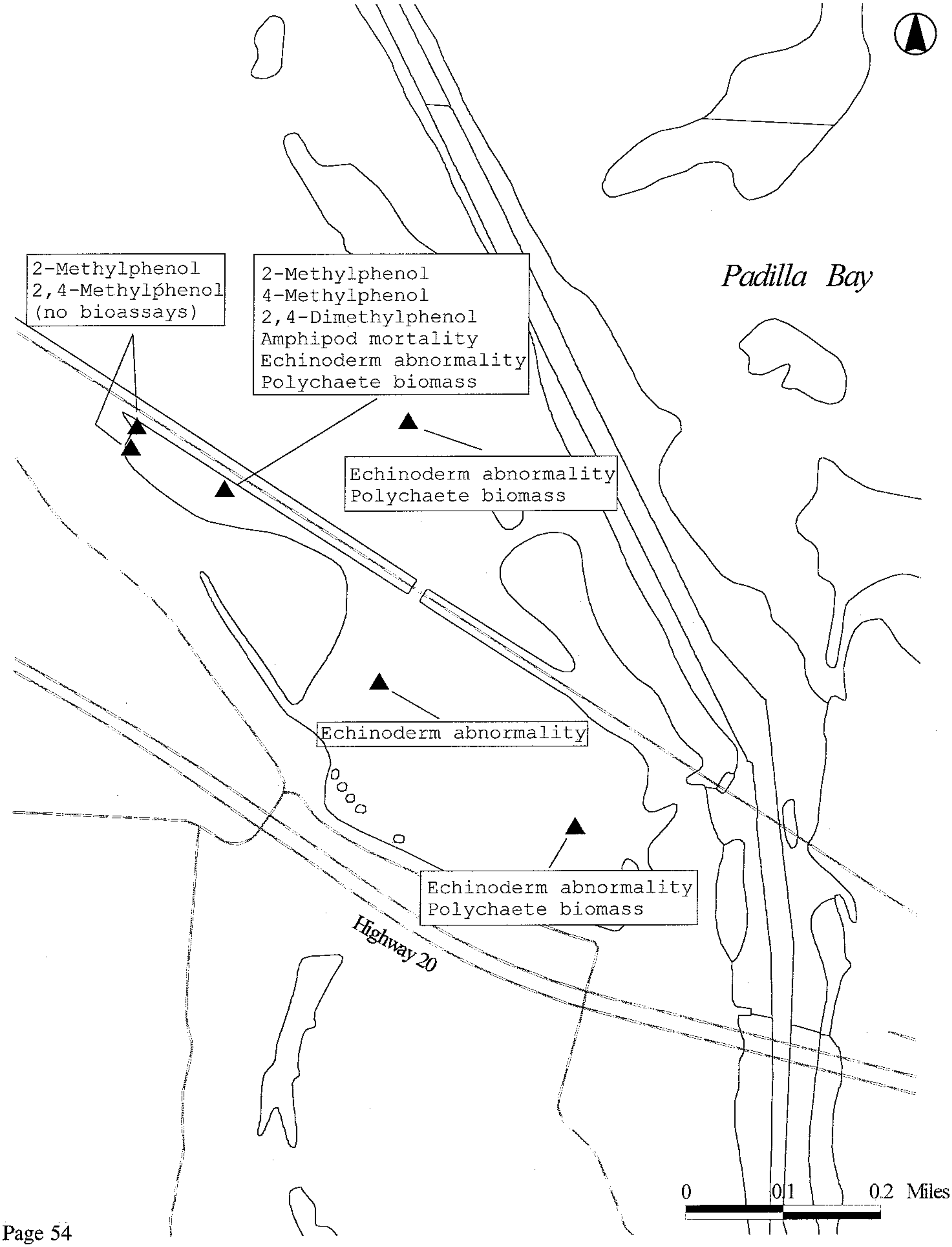


Figure 7. Sites Exceeding Cleanup Screening Levels in Padilla Bay Lagoon, 1998

ranked and assigned a priority for cleanup. Station clusters that meet neither of these conditions are defined as clusters of low concern and receive no further consideration for active cleanup.

The following sites in Padilla Bay Lagoon qualify as station clusters of potential concern:

- Sites #1, #2, and #3: average concentrations of 2-methylphenol, 4-methylphenol, and 2,4-dimethylphenol exceed CSLs.
- Sites #3, #4, #5, and #6: sea urchin abnormality exceeds CSL at each site.

Apparent Effects Thresholds

The sediment standards are based on Apparent Effects Thresholds (AETs). An AET is defined as the concentration of a chemical in sediments above which statistically significant biological effects would always be expected to occur (PTI, 1989). The AET approach uses simultaneously collected data on sediment chemistry, sediment bioassays, and benthic infauna.

AETs based on data too limited for establishing standards are available for 15 additional chemicals detected in the lagoon. These are listed in Table 11 along with the range of concentrations seen in the study area.

Chemicals substantially exceeding these AETs are beryllium at site #6; ethylbenzene, xylenes, and dibenzothiophene at site #3; and coprostanol at sites #1 and #2. The AET of 0.36 mg/Kg shown for beryllium is questionable. Beryllium concentrations average about 1.5 mg/Kg in Puget Sound, with a 90^{th} percentile value of 5.5 mg/Kg (SEDQUAL).

No AETs were available for iron, but the levels of 47,000 - 47,500 mg/Kg near the landfill may be a concern, as they exceed guidelines for freshwater sediments. Persaud et al. (1993), for example, concluded that iron concentrations above 4% (40,000 mg/Kg) have a severe adverse effect on freshwater benthic invertebrates. Iron concentrations in other parts of the lagoon were equal to or less than the average value of 27, 000 mg/Kg in Puget Sound (SEDQUAL).

Dioxins and Furans

To put the results for PCDDs/PCDFs in perspective, the dioxin TEQs in the lagoon sediments were compared with similar data for North Puget Sound (Table 12). The data are arranged in order of increasing TEQs. Because of higher detection limits, the data on other samples in reference areas result in somewhat lower TEQs than present study findings for Samish Bay.

Table 11. AETs for Non-SMS Chemicals Detected in Padilla Bay Lagoon and Reference Area

	Concentration Range (ug/Kg, dry)	Location of Maximum	Lowest AET	Highest AET
Metals (mg/Kg, dry)				
Antimony	3 UJ - 15 UJ	nd	200	- -
Beryllium	0.5 U - 3.0	#6	0.36	- -
Nickel	26 - 51	#1	>140	>140
Selenium	0.3 U - 0.40	#3	1.0	- -
Thallium	0.3 UJ - 25 U	nd	0.24	0.40
Organics (ug/Kg, dry)				
Ethylbenzene	2.5 U - 260 J	#3	10	37
Total Xylene	2.5 U - 2420 J	#3	40	120
Isopropyltoluene	2.5 U - 34	#3	600	2800
1-Methylphenanthene	52 U - 287 J	#1	370	1300
2-Methylphenanthrene	52 U - 61 J	#1	470	1500
Dibenzothiophene	35 U - 145 J	#3	240	950
Carbazole	52 U - 9.8 J	ref. area	970	3600
Coprostanol	188 - 3370	#1/#2	140	160
Biphenyl	52 U - 6.5 J	ref. area	260	310
Retene	13 J - 184	#1	1700	2000

Sources: PTI (1989) except antimony and nickel from PTI (1988b)
AET = Apparent Effects Threshold
U = Not detected at or above reported value (i.e., less than)
J = The analyte was positively identified; associated numerical value is an estimated.

Table 12 . Dioxin TEQs in Northern Puget Sound Sediments
[ng/Kg, dry]

Location	TEQ* median	TEQ* range	N =	Reference
Reference Areas				
Dungeness Bay	0.02	0 - 0.12	3	Ecology & Environment (1998)
Samish Bay	0.04	0.034 - 0.044	2	CH2M Hill (1992a,b)
" "	0.15	- -	1	present study
Urban/Industrial Areas				
Padilla Bay, outside lagoon	0.012	- -	1	present study
Outer Port Angeles Harbor	0.23	0.13 - 2.91	4	Ecology & Environment (1998)
March Point, Shell outfall	0.34	0.29 - 0.39	2	CH2M Hill (1992a)
March Point, Texaco outfall	0.32	0.28 - 0.36	2	CH2M Hill (1992b)
Inner Port Angeles Harbor	3.3	0.63 - 4.67	6	Ecology & Environment (1998)
Duwamish Waterway	3.6	1.22 - 4.39	3	Ecology (unpublished)**
Padilla Bay Lagoon	4.0	0.22 - 5.7	5	present study
Bellingham Bay, near pulp mill outfall	83	- -	1	Golding (1994)
Everett Harbor, near pulp mill outfall	110	- -	1	Anderson & Jones (1997)

*2,3,7,8-TCDD Equivalence
**Data provided by Bill Yake

The TEQ of 0.012 ng/Kg in sediments outside Padilla Bay Lagoon is among the lowest reported for the north sound. With the exception of site #5, TEQs inside the lagoon, 1.7 - 5.7 ng/Kg, are an order of magnitude higher than found at the Shell and Texaco outfalls off March Point and comparable to those in Inner Port Angeles Harbor and Duwamish Waterway, both heavily industrialized areas. The high TEQs of 83 and 110 ng/Kg shown for Bellingham Bay and Everett Harbor were in sediment samples near outfalls of chlorine bleach pulp mills.

Ecology has no sediment standards for these compounds. EPA (1993) has calculated that the following sediment concentrations of 2,3,7,8-TCDD (ng/Kg, dry) may pose a risk to aquatic life and associated wildlife:

Organism	Low Risk	High Risk (Sensitive Species)
Fish	60	100
Mammalian Wildlife	2.5	25
Avian Wildlife	21	210

By way of comparison, the Model Toxics Control Act (MTCA) Cleanup Level for 2,3,7,8-TCDD in residential soil is 6.7 ng/Kg (soil ingestion).

According to the Swinomish Tribe, Padilla Bay Lagoon is not a seafood harvest area (Aundrea Noffke, personal communication).

Based on the above, it appears that dioxin TEQs are elevated in the sediments of Padilla Bay Lagoon and in the range encountered in some local industrial waterways. The elevations do not, however, appear sufficient to pose a significant hazard to fish or wildlife.

Sources of Sediment Contamination

Ecology and Skagit County data on Whitmarsh seepage show the seepage is a source of the three phenols that exceed CSLs in the inner lagoon and that the landfill is discharging other chemicals that are elevated in the sediments. Given the low concentrations in the seepage, it is unclear whether the landfill is currently a significant source, or the contamination is primarily from historical discharges or from other sources.

The concentration gradients in the sediments support some tentative conclusions about which contaminants are or are not associated with the landfill.

Figure 8 plots the data for metals that were elevated over reference sediments by at least a factor of 2. Because factors other the sources (e.g., clay minerals, iron and manganese oxides, etc.) can affect the distribution of metals in sediments, the data were normalized to aluminum, a conservative element, to help clarify metal distribution patterns (Horowitz, 1985).

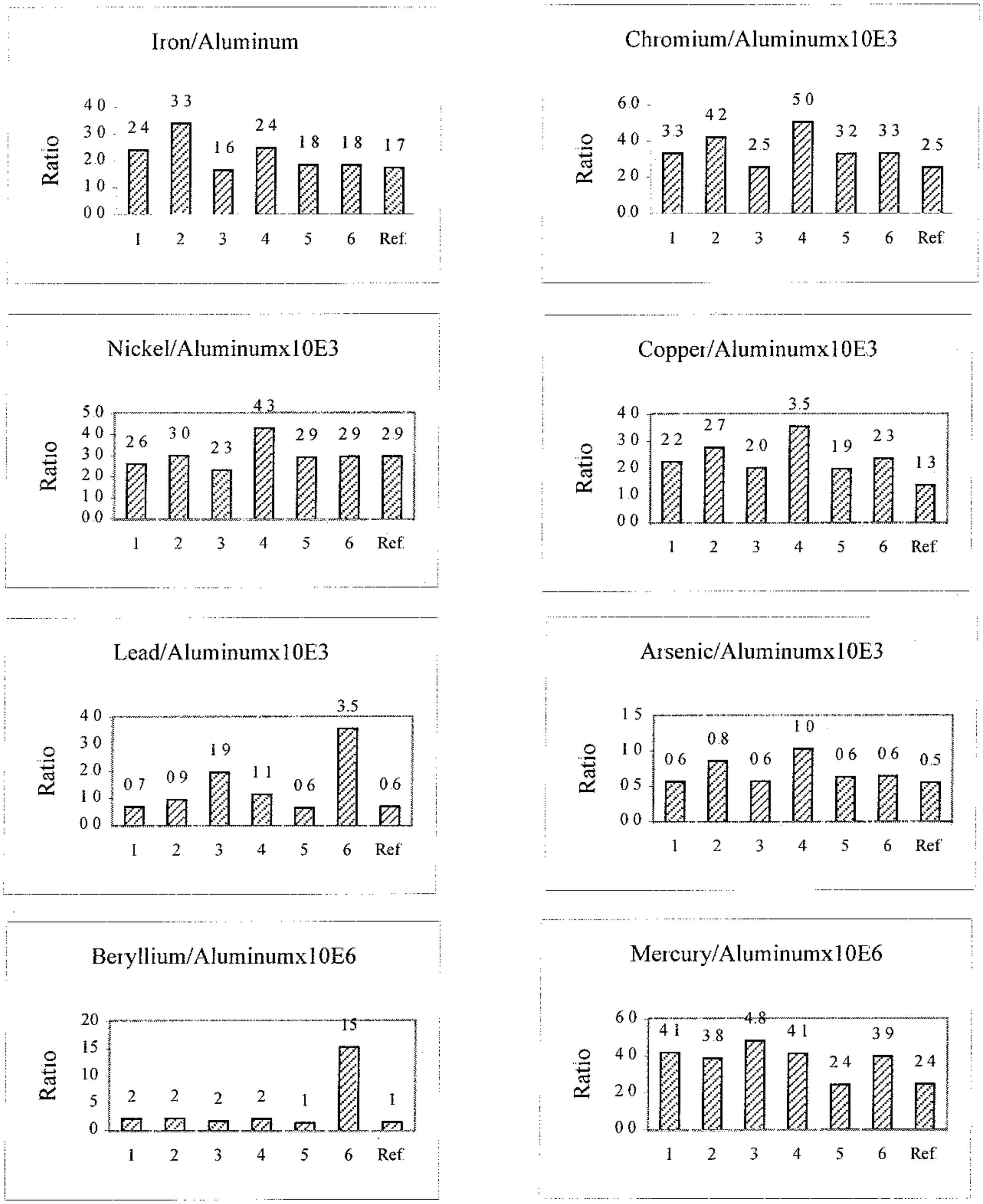


Figure 8. Concentration Gradients for Selected Metals in Padilla Bay Lagoon Sediments
(Non-detects plotted at 1/2 detection limit,)

Beyond some elevation in iron near the fill, there is not much support for concluding the landfill has been a significant source of metals contamination. The high ratios of lead and beryllium to aluminum at site #6 suggest a source for these metals outside the lagoon.

The distribution of selected organic compounds is shown similarly in Figure 9. The data for non-polar compounds were normalized to TOC to minimize gradients due to simple differences in organic carbon. The low TOC in the reference sediments makes it appear there is significant contamination for some of the normalized chemicals (e.g., PAH). When TOCs are extremely low, it is possible for background concentrations of organic compounds to exceed standards when normalized (Michelsen, 1992)

The graphs show reasonably consistent-to-strong trends toward decreasing concentrations of bis(2-ethylhexyl)phthalate, dibenzofuran, retene, and coprostanol moving away from the landfill. A source in the inner lagoon is indicated for LPAH and 4-methylphenol. Other phenolic compounds — phenol, 2-methylphenol, 2,4-dimethylphenol, and 4-nitrophenol — were only detected in the inner lagoon, although the highest concentrations were at site #3. While it is unclear if the landfill has been an important contributor to dioxin TEQs in the lagoon, 2,3,7,8-TCDD was only detected in the sediments adjacent to Whitmarsh.

An additional potential source of 4-methylphenol is wood waste from the sawmill that had been built over the fill. The log storage area for this facility borders the lagoon. As noted at the beginning of this report, the mill, located on the west side of the property away from the lagoon, burned down midway between the June and August sediment collections. Given its distance and lack of a route for runoff to reach the lagoon, it seems unlikely the fire was a significant source of the contamination detected in the sediment samples.

The landfill seepage contains HPAH, but an additional source or sources outside the inner lagoon are indicated. There are a number of possibilities. For the outer lagoon these include runoff from Highway 20, as well as creosote from the BNRR tracks and pilings. The two most likely sources of HPAH to the area outside the lagoon are engine exhaust from vessel traffic in Swinomish Channel and the petroleum refineries on March Point. Barrick and Prahl (1987) concluded the HPAH patterns they observed in the sediments around March Point were due to combustion sources, possibly from the refinery flare towers. Ecology has also detected elevated HPAH in sediments near March Point (Johnson et al., 1997).

A final question is the source of the contamination at site #3. Distance from the landfill argues against that being the source. A spill from the BNRR tracks is a plausible explanation.

On the other hand, the drainage channel in the inner lagoon flows north along the face of the landfill and then turn west to parallel the railroad, passing through site #3. Except at higher tides, the inner lagoon is dry other than the drainage channel. This leaves open the possibility that site #3 was contaminated from past discharge of a dense product that flowed out of the landfill.

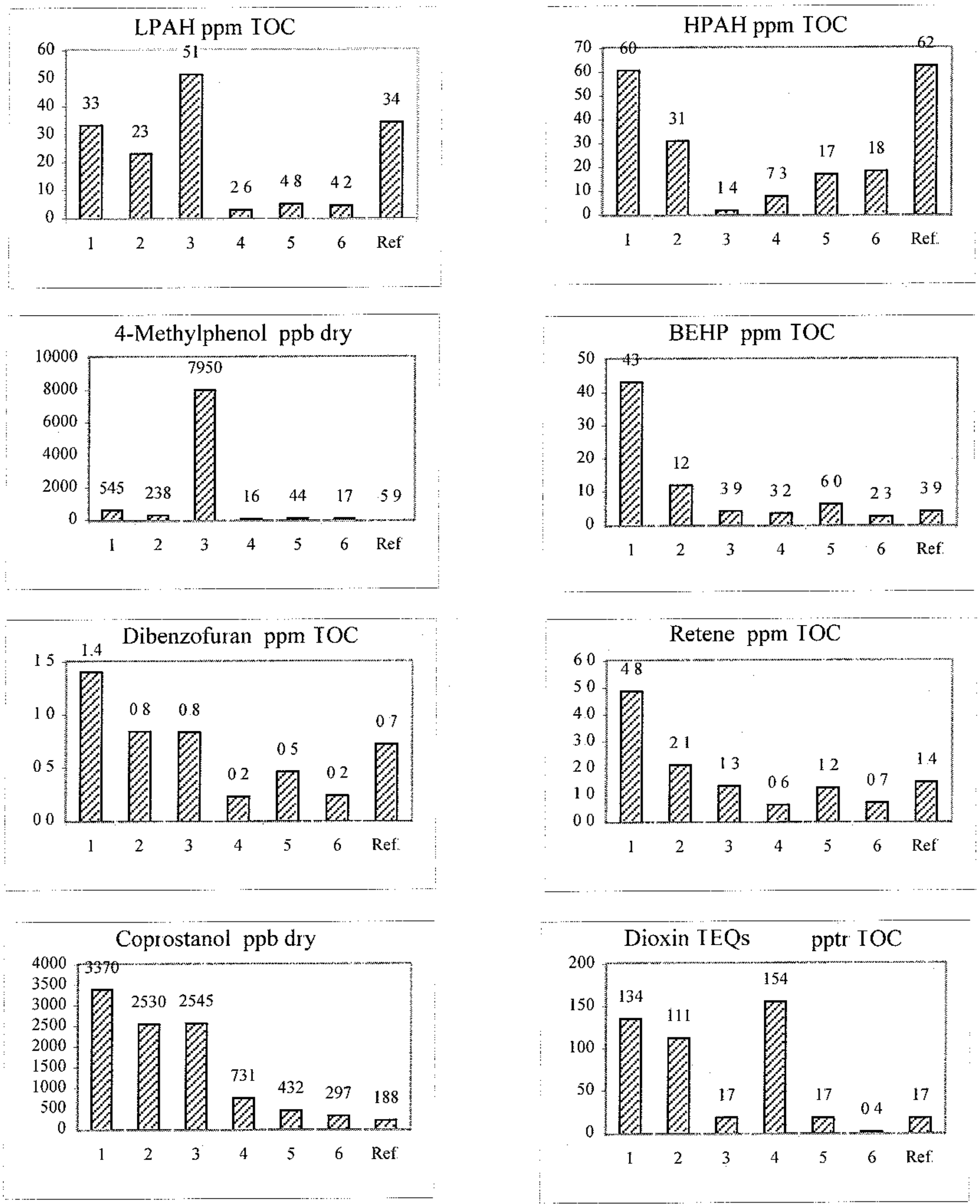


Figure 9. Concentration Gradients for Selected Organics in Padilla Bay Lagoon Sediments
(Non-detects plotted at 1/2 detection limit.)

Conclusions

Seepage from Whitmarsh Landfill is a source of toxic chemical contamination to Padilla Bay Lagoon. The chemicals of concern include iron, petroleum, benzenes, chlorinated benzenes, toluene, xylene, ethylether, PAH, phenols, phthalates, nitrosodiphenylamine, dibenzofuran, carbazole, dibenzothiophene, PCBs, and carbaryl. For the most part, the concentration levels are low and unlikely to cause toxicity in the lagoon water column. Sensitive marine species could be adversely affected by carbaryl levels in the immediate vicinity of the fill.

The lagoon sediments exceed Cleanup Screening Levels for 2-methylphenol, 4-methylphenol, 2,4-dimethylphenol, and the echinoderm larvae bioassay. Other semivolatiles and dioxin TEQs are also elevated in the sediments. The landfill appears to be responsible to some degree for the phenols contamination as well as the elevations in iron, LPAH, bis(2-ethylhexyl)phthalate, 2,3,7,8-TCDD, dibenzofuran, retene, and coprostanol (an indicator of fecal matter). Past studies have shown the sediments adjacent to the fill are toxic, but the source of sediment toxicity in the wider lagoon is unclear. There is a petroleum/phenols hotspot of unknown origin at site #3, on the north side of the inner lagoon, adjacent to the BNRR tracks.

References

Aly, O.M. and M.A. El-Dib. 1971. Studies on the Persistence of Some Carbamate Insecticides in the Aquatic Environment – I. Hydrolysis of Sevin, Baygon, Pyrolan, and Dimetilan. Water Res. 5:1191-1205.

Anderson, J. and J. Jones. 1997. Response of the P450RGS Assay to Extracts of Sediments Collected from Puget Sound, WA. Report to Ed Long, NOAA, Seattle. Columbia Analytical Services, Carlsbad, CA.

ATSDR. 1992. Toxicological Profile for Nitrophenols: 2-Nitrophenol and 4-Nitrophenol. Agency for Toxic Substances and Disease Registry, U.S. Public Health Service.

Barrick, R.C. and F. Prahl. 1987. Hydrocarbon Geochemistry of the Puget Sound Region III: Polycyclic Aromatic Hydrocarbons in Sediments. Estuar. Coast. Shelf Sci. 25:175-191.

Buchanan, D.V., D.L. Bottom, and D.A. Armstrong. 1985. The Controversial Use of the Insecticide Sevin in Pacific Northwest Estuaries: Its Effects on Dungeness Crab, Pacific Oysters, and Other Species. In: Proceedings of the Symposium on Dungeness Crab Biology and Management, Anchorage, AK, Oct. 9-11, 1984

Bulthuis, D.A. and T. Shaw. 1992. Acute Toxicity of Intertidal Sediments from Padilla Bay, Washington, to the Amphipod, *Rhepoxynius abronius*. Padilla Bay Estuarine Research Reserve, Mount Vernon, WA. Tech. Rept. No. 4.

Carrell, B. 1998. Case Narrative: Hydrocarbon Identification Analysis, Whitmarsh Landfill Project. Manchester Environmental Laboratory. Washington State Department of Ecology, Manchester, WA.

CH2M Hill. 1992a. Sediment Studies Report, NPDES Permit No. 000294-1, Texaco USA, Anacortes.

CH2M Hill. 1992b. Sediment Studies Report, NPDES Permit No. 000976-1, Shell Oil Company, Anacortes.

Ecology. 1984. Potential Hazardous Waste Site Preliminary Assessment, March Point Landfill, Summary Memorandum. Washington State Department of Ecology, Olympia, WA.

Ecology. 1995a. Sediment Management Standards. Washington Administrative Code (WAC) Chapter 173-204. Olympia, WA.

Ecology. 1995b (draft). Guidance on the Development of Sediment Sampling and Analysis Plans Meeting the Requirements of the Sediment Management Standards. Washington State Dept. Ecology, Olympia, WA.

Ecology. 1996. Sediment Management Standards Contaminated Sediment Site List. Sediment Management Unit, Washington State Dept. Ecology, Olympia, WA.

Ecology and Environment. 1998. Rayonier Pulp Mill Expanded Site Inspection. Prep. for EPA Region 10, Seattle, WA.

EPA. 1977. Quality Criteria for Water. U.S. Environmental Protection Agency.

EPA. 1983. Methods for Chemical Analysis of Water and Wastes. U.S. Environmental Protection Agency. EPA-600/4-79-020 (Rev. March 1983)

EPA. 1986a. SW-846: Test Methods for Evaluating Solid Waste. U.S. Environmental Protection Agency, EMSL, Cincinnati, OH.

EPA. 1987. Characterization of Leachates from Landfills from Municipal Waste Disposal Sites and Co-Disposal Sites. U.S. Environmental Protection Agency, EPA Office of Solid Waste and Emergency Response. EPA-530-SW-87-028F.

EPA. 1990. Specifications and Guidance for Obtaining Contaminant-Free Sample Containers. U.S. Environmental Protection Agency, OSWER Directive #93240.0-05

EPA. 1991. Pollutants of Concern in Puget Sound. Prep. for U.S. Environmental Protection Agency, Region 10. PTI Environmental Services, Bellevue, WA.

EPA. 1993. Interim Report on Data and Methods for Assessment of 2,3,7,8-Tetrachlorodibenzo-p-dioxin Risks to Aquatic Life and Associated Wildlife. U.S. Environmental Protection Agency, Office of Research and Development. EPA 600/R93-055.

Fitzpatrick, K. 1989. Letter to John Thayer, Skagit County Dept. of Health, re: Analysis of Leachate from the Whitmarsh Landfill. Washington State Department of Ecology, Bellevue, WA.

Golding, S. 1994. Georgia-Pacific Corporation (Bellingham) April 1993 Class II Inspection. Washington State Department of Ecology, Olympia, WA. Pub. No. 94-54.

Hem, J.D. 1970. Study and Interpretation of the Chemical Characteristics of Natural Water. U.S. Geological Survey Water-Supply Paper 1473.

Horowitz, A.J. 1985. A Primer on Trace Metal-Sediment Chemistry. U.S. Geological Survey Water-Supply Paper 2277.

Johnson, A. 1989. Analysis of Padilla Bay Intertidal Sediments for Cresylic Acid Memorandum to K. Fitzpatrick. Washington State Department of Ecology, Olympia, WA.

Johnson, A. D. Serdar, and D. Davis. 1997. Survey of Petroleum and Other Chemical Contaminants in the Sediments of Fidalgo Bay. Washington State Department of Ecology, Olympia, WA. Pub. No. 97-338.

Kmet, P. 1982. A Short Course on Landfill Leachate and Methane Gas Generation and Control. Washington State Department of Ecology, Olympia, WA.

Lake, J.L., C. Norwood, C. Dimock, and R. Bowen. 1979. Origins of Polycyclic Aromatic Hydrocarbons in Estuarine Sediments. Geochim. Cosmochim. Acta 43:1847-1854.

MEL. 1994. Lab Users Manual. Manchester Environmental Laboratory. Washington State Departmment of Ecology, Manchester, WA.

Michelsen, T.C. 1992. Organic Carbon Normalization of Sediment Data. Technical Information Memorandum. Sediment Management Unit, Washington State Department of Ecology, Olympia, WA.

Michelsen, T.C. and K. Bragdon-Cook. 1993. Organic Carbon Normalization of Sediment Data. Technical Information Memorandum. Sediment Management Unit, Washington State Department of Ecology, Olympia, WA

Milham, S.E. 1986. Site Inspection Report, March Point Landfill, Anacortes, Washington. Washington State Department of Ecology, Olympia, WA.

NAS. 1973. Water Quality Criteria 1972. National Academy of Sciences. EPA-R3-73-033.

Ogden. 1998. Sediment Toxicity Testing Report. Prep. for Washington State Dept. Ecology by Ogden Environmental and Energy Services Co., San Diego, CA. Project. No. 318861000 0001

Olson, N. 1998. Case Narrative: Neutral Pesticide Analysis, Whitmarsh Landfill Project. Manchester Environmental Laboratory. Washington State Department of Ecology, Manchester, WA.

Persaud, D., R. Jaagumagi, and A. Hayton. 1993. Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario. Ontario Ministry of Environment and Energy. ISBN 0-7729-9248-7.

Prahl, F.G. and R. Carpenter. 1984. Hydrocarbons in Washington Coastal Sediments. J. Estuarine Coastal Mar. Sci. 18:703-720.

PSEP (Puget Sound Estuary Program). 1995. Recommended Guidelines for Conducting Laboratory Bioassays on Sound. EPA Region 10, Office of Puget Sound, Seattle, WA and Puget Sound Water Quality Authority, Olympia, WA.

PSEP. 1996. Puget Sound Estuary Program (PSEP): Recommended Protocols for Measuring Selected Environmental Variables in Puget Sound. EPA Region 10, Office of Puget Sound, Seattle, WA.

PTI. 1988a. Puget Sound Dredge Disposal Analysis, Baseline Survey for Phase I Disposal Sites. Prep. for Washington State Department of Ecology. PTI Environmental Services, Bellevue, WA.

PTI. 1988b. Sediment Quality Values Refinement: Tasks 3 and 5 - 1988 Update and Evaluation of Puget Sound AET. Prepared for EPA Region 10. PTI Environmental Services, Bellevue, WA.

PTI. 1989. Contaminated Sediments Criteria Report. Prep. for Washington State Dept. Ecology. PTI Environmental Services, Bellevue, WA.

PTI. 1991. Reference Area Performance Standards for Puget Sound. Prepared for EPA Region 10. PTI Environmental Services, Bellevue, WA.

Rich, L. 1998. Personal communication. Office of Planning and Community Development, Swinomish Tribal Community.

Shigenaka, G. and J.E. Price. 1988. Correlation of Coprostanol to Organic Contaminants in Coastal and Estuarine Sediments of the U.S. Water Resources Bull. 24(5):989-998.

Stewart, M.E., R.E. Millemann, and W.P. Breese. 1967. Acute Toxicity of the Insecticide Sevin and Its Hydrolytic Product 1-Napthol to Some Marine Organisms. Trans. Amer. Fish. Soc. 96:25-30.

Tetra Tech. 1985. Commencement Bay Nearshore/Tideflats Remedial Investigation. Prepared for Washington State Department of Ecology and EPA. EPA-910/9-85-134b.

USFWS. 1994. Trace Elements and Oil-Related Contaminants in Sediment, Bivalves, and Eelgrass from Padilla and Fidalgo Bays, Skagit County, Washington, 1988. U.S. Fish and Wildlife Service, Olympia, WA.

Wiggins, J.R. 1992. The Effect of Landfill Leachate from Padilla Bay on the Abundance of Epibenthic Harpacticoid Copepods and Sediment Toxicity Measured with the Amphipod Bioassay (*Rhepoxynius abronius*). M.S. Thesis, Western Washington Univ., Bellingham, WA.

Willis, K. 1996. Letter to Lauren Rich, Swinomish Tribe re: Whitmarsh Landfill Sample Data Results. Skagit County Dept. Health, Mount Vernon, WA.

Yake, B., S. Singleton, and K. Erickson 1998. Washington State Dioxin Source Assessment. Washington State Department of Ecology, Olympia, WA. Pub. No. 98-320.

Appendix A

Appendix A. Locations of Ecology 1998 Sediment Samples from Padilla Bay Lagoon

Location	Site	Sample Number	Date	Latitude (48°N)	Longitude (122°W)	Depth (ft.)	Time
Inner Lagoon							
NW corner near landfill	1	248007	6/11/98	27'49.8"	31'40.7"	dry	1200
SW corner near landfill	2	248008	6/11/98	27'49.0"	31'41.2"	dry	1215
North side along BNRR	3	328004	8/7/98	27'47.0"	31'34.4"	3	1810
Outer Lagoon							
West end	4	320883	8/7/98	27'37.8"	31'21.1"	4	1740
East end	5	328002	8/7/98	27'29.3"	31'05.2"	4	1650
Outside Lagoon							
West of green can buoy"29"	6	328001	8/7/98	27'50.8"	31'19.3"	2	1550
Samish Bay							
North of Samish Is. isthmus	Ref. Area	328000	8/7/98	34'53.5"	32'14.3"	55	1300

Appendix B

State of Washington Department of Ecology

Program Code D32F2

SAMPLE DATA & ANALYSIS REQUIRED

183198

Project Code ____________

Project/Name Whitmarsh Landfill

☐ Enforcement/Custody ☐ Class II

☐ Possible Toxic/Hazardous Notes No matrix spikes on organics; low detection limits for BNAs/PCBs; use NOAA list for BNAs.

Date Yr	Date Mo	Date Da (G.9)	Time Hr	Time Mn	Field Station Identification	Lab Sample Number Wk	Lab Sample Number Seq	Matrix Code	Source Code	No. of Containers
98	06	17			N Seep	24	8005	10	38	20
↓					S Seep	24	8006	10	38	20
↓					N. Sed.	24	8007	40	14	6
↓					S. Sed.	24	8008	40	14	6

General Chemistry

Station	Turbidity	pH	Conductivity	Total Hardness	Chloride	TS, TSS, TNVS, TNVSS	TSS	% Solids	Nutrients (4)	Ammonia	Nitrate-Nitrite	Total Phosphorous	Ortho-Phosphate	BOD/5 Day	COD Chem Oxy Demand	Cyanide	Salinity	TOC	~~X~~
N Seep	X	X	X				X			X	X	X				X	X	X	
S Seep	X	X	X				X			X	X	X				X	X	X	
N. Sed.																		X	
S. Sed.																		X	

Biology

Station	Fecal Coliform Bacteria	Total Coliform Bacteria	Enterococcus	Fish Bioassay
N Seep				
S Seep				
N. Sed.				
S. Sed.				

Organic Chem.

Station	Base/Neutrals/Acids + TICs (Ext)	Volatile Organics + TICs	Pesticides/PCB's	PCB's Only	Purgeable Halocarbons	Herbicides (Chlorinated)	Hydrocarbon Analysis DOE	Phenolics (AAP)	Oil & Grease	OP/OC/N Pest RL	Carbamates	Dioxins/Furans	Organotins TBT
N Seep	X	X		X		X	X			X	X		
S Seep	X	X		X		X	X			X	X		
N. Sed.	X			X		X	X			X		X	X
S. Sed.	X			X		X	X			X		X	X

METALS — Specific List: Total ☑ Recoverable ☐ Totals ☐ Dissolved

Station	ICP Metals Scan (23)	EP Tox Metals	Hg
N Seep	X		X
S Seep	X		X
N. Sed.	X		X
S. Sed.	X		X

Project Officer Art Johnson

Sampler(s) Art Johnson

Recorder Art Johnson

Date 98/06/12 G.9

Chain Of Custody Record

Relinquished By:	Received By:	Yr	Mo	Da	Hr	Mn	Seal I.D.	Condition of Seals	Comments
[signature]		98	06	11	16	30	0013923 tapes 001101-001104		
	P Carey	98	06	12	08	30	0013923 001103 001104	001102 001101	Green seal intact (0013923) Blue seals could be peeled w/o breaking

Laboratory Copy White — Project Office Copy Yellow — Field or Office Copy Pink

Ecy 040-115 Rev. 7/87

Project ID# 25528

Laboratory Analyses Required

Project Name: Whitmarsh Landfill

IC: D3201 Program: EILS

Send Results to: Art Johnson Mail Stop: HQ

☑ Preliminary Investigation ☐ Monitoring

☐ For HW Designation ☐ For NPDES

Date Results needed by: ____________

☐ There is a QAPP for this project

General Chemistry (unmarked columns): Alkalinity, Conductivity, Hardness, pH, Turbidity, ☐ Chloride ☐ Sulfate, Cyanide ☐ Total ☐ Weak, Total Solids, Total Nonvolatile Solids, Total Suspended Solids, Total Nonvol Suspend, Total Dissolved Solids, ☐ %Solids ☐ %Vol Solids, BOD (5 day), Oil & Grease, Ammonia, Nitrate-Nitrite, Total Phos ☐ low level, Orthophos ☐ low level, Nitrate, Nitrite, ☐ TPN ☐ TKN, Chlorophyll ☐ filters

~~Micro~~ BIOASSAY (unmarked columns): Fecal Coliforms ☐ MF ☐ MPN, Total Coliforms ☐ MF ☐ MPN, E-Coli ☐ MF ☐ MPN, %Klebsiella

Metals (unmarked columns): ICP Scan, ICP/MS scan, TCLP Metals, Mercury (Hg), GFAA list individually; ☐ Total ☐ Total Rec. ☐ Dissolved

Organic Chemistry (unmarked columns): PAH s, BTEX, Pests/PCB s, OP- Pests, Herbicides, WTPH-HCID, WTPH-G, WTPH-418.1 Modified, HCID Only

BNA ☐ w/unknown TIC's: Top 20, +NOAA; VOA ☐ w/unknown TIC's: Top 10

Date (Mo/Da), Year: 1998	Time (Hr/Mn)	Field Station Identification	Lab Sample Number	Matrix Code	Source Code	No. of Containers	TOC	Grain Size	Amphipod	Echinoderm	Polychaete	PP Metals	Iron, Aluminum	BNA	VOA	PCB's only	WTPH-D	Dioxins/Furans
807		Samish	328000	40	14	8	X	X	X	X	X	X	X	X	X	X	X	X
↓		Padilla	1	↓	↓	↓	X	X	X	X	X	X	X	X	X	X	X	X
↓		Lagoon E	2	↓	↓	↓	X	X	X	X	X	X	X	X	X	X	X	X
↓		Lagoon mid	3	↓	↓	↓	X	X	X	X	X	X	X	X	X	X	X	X
↓		Lagoon W	328004	↓	↓	↓	X	X	X	X	X	X	X	X	X	X	X	X

Project Officer: Art Johnson

Phone number: 4076766

Samplers: A. Johnson, D. Serdar

Recorder: A. Johnson

Date: Aug 7, 1998

Chain of Custody Record

Relinquished By:	Received By:	Yr	Mo	Da	Hr	Mn	Seal I.D.	Condition of Seals	Comments
Art Johnson		98	08	07	10	10	0008289, 0008332, 0008340	Bioassay	
	P Carey	98	08	10	08	50	0008285, 0008332, 0008340	Intact	

Comments:
1. NOAA list for BNAs
2. Low detection limits for BNAs and PCBs
3. Do matrix spikes on sample number 328000

ECY 040-115 Rev. 4/96

9 10

Appendix C

Appendix C. Target Chemicals for Ecology 1998 Investigation at Whitmarsh Landfill

CAS No.	Chemical Name	CAS No.	Chemical Name
86290815	Gasoline	**Volatile Organics**	
68334305	Diesel	56235	Carbon Tetrachloride
57125	Cyanide	60297	Ethyl Ether
		67641	Acetone
Priority Pollutant Metals		67663	Chloroform
7440360	Antimony	67721	Hexachloroethane
7440382	Arsenic	71432	Benzene
7440417	Beryllium	71556	1,1,1-Trichloroethane
7440439	Cadmium	74839	Bromomethane
7440473	Chromium	74873	Chloromethane
7440508	Copper	74884	Methyl Iodide
7439921	Lead	74953	Dibromomethane
7439976	Mercury	74975	Bromochloromethane
7440020	Nickel	75003	Chloroethane
7782492	Selenium	75014	Vinyl Chloride
7440224	Silver	75092	Methylene Chloride
7440280	Thallium	75150	Carbon Disulfide
7440666	Zinc	75252	Bromoform
		75274	Bromodichloromethane
Misc. Trace Elements		75343	1,1-Dichloroethane
7429905	Aluminum	75354	1,1-Dichloroethene
7439896	Iron	75694	Trichlorofluoromethane
7439954	Magnesium	75718	Dichlorodifluoromethane
7439965	Manganese	76017	Pentachloroethane
7439987	Molybdenum	76131	1,1,2 Trichlorotrifluoroethane
7440097	Potassium	78875	1,2-Dichloropropane
7440235	Sodium	78933	2-Butanone
7440246	Strontium	79005	1,1,2-Trichloroethane
7440326	Titanium	79016	Trichloroethene
7440393	Barium	79345	1,1,2,2-Tetrachloroethane
7440484	Cobalt	79469	2-Nitropropane
7440622	Vanadium	80626	Methyl Methacrylate
7440702	Calcium	87616	1,2,3-Trichlorobenzene
		87683	Hexachlorobutadiene
		91203	Naphthalene
		95476	o-Xylene

Appendix C. Target Chemicals (continued)

CAS No.	Chemical Name
Volatile Organics	
95498	2-Chlorotoluene
95501	1,2-Dichlorobenzene
95636	1,2,4-Trimethylbenzene
96128	1,2-Dibromo-3-Chloropropane
96184	1,2,3-Trichloropropane
96333	Methyl acrylate
97632	Ethylmethacrylate
98066	Tert-Butylbenzene
98828	Isopropylbenzene (Cumene)
99876	p-Isopropyltoluene
100414	Ethylbenzene
100425	Styrene
103651	n-Propylbenzene
104518	n-Butylbenzene
106434	4-Chlorotoluene
106467	1,4-Dichlorobenzene
106934	1,2-Dibromoethane (EDB)
107051	Allyl Chloride
107062	1,2-Dichloroethane
107131	Acrylonitrile
108101	4-Methyl-2-Pentanone
108678	1,3,5-Trimethylbenzene
108861	Bromobenzene
108883	Toluene
108907	Chlorobenzene
109693	1-Chlorobutane
109999	Tetrahydrofuran
110576	Trans-1,4-Dichloro-2-butene
120821	1,2,4-Trichlorobenzene
124481	Dibromochloromethane
126987	Methyacrylonitrile
127184	Tetrachloroethene
135988	Sec-Butylbenzene
142289	1,3-Dichloropropane
156592	Cis-1,2-Dichloroethene
156605	Trans-1,2-Dichloroethene

CAS No.	Chemical Name
Volatile Organics	
513882	1,1-Dichloropropanone
541731	1,3-Dichlorobenzene
563586	1,1-Dichloropropene
591786	2-Hexanone
594207	2,2-Dichloropropane
630206	1,1,1,2-Tetrachloroethane
1330207	m & p-Xylene
1634044	2-Methyoxy-2-Methylpropane
10061015	Cis-1,3-Dichloropropene
10061026	Trans-1,3-Dichloropropene
Semivolatile Organics	
50328	Benzo(a)pyrene
51285	2,4-Dinitrophenol
53703	Dibenzo(a,h)anthracene
56553	Benzo(a)anthracene
58082	Caffeine
59507	4-Chloro-3-Methylphenol
62533	Aniline
62759	N-Nitrosodimethylamine
65850	Benzoic Acid
67721	Hexachloroethane
77474	Hexachlorocyclopentadiene
78591	Isophorone
83329	Acenaphthene
84662	Diethylphthalate
84742	Di-N-Butylphthalate
85018	Phenanthrene
85687	Butylbenzylphthalate
86306	N-Nitrosodiphenylamine
86737	Fluorene
86748	Carbazole
87683	Hexachlorobutadiene
87865	Pentachlorophenol
88062	2,4,6-Trichlorophenol
88744	2-Nitroaniline

Appendix C. Target Chemicals (continued)

CAS No.	Chemical Name	CAS No.	Chemical Name
Semivolatile Organics		**Semivolatile Organics**	
88755	2-Nitrophenol	120832	2,4-Dichlorophenol
88755	2-Nitrophenol	121142	2,4-Dinitrotoluene
90120	1-Methylnaphthalene	122667	1,2-Diphenylhydrazine
90120	1-Methylnaphthalene	129000	Pyrene
91203	Naphthalene	131113	Dimethylphthalate
91203	Naphthalene	132649	Dibenzofuran
91576	2-Methylnaphthalene	132650	Dibenzothiophene
91587	2-Chloronaphthalene	191242	Benzo(ghi)perylene
91941	3,3'-Dichlorobenzidine	192972	Benzo[e]pyrene
92524	1,1'-Biphenyl	193395	Indeno(1,2,3-cd)pyrene
92875	Benzidine	198550	Perylene
95487	2-Methylphenol	205992	Benzo(b)fluoranthene
95501	1,2-Dichlorobenzene	206440	Fluoranthene
95578	2-Chlorophenol	207089	Benzo(k)fluoranthene
95954	2,4,5-Trichlorophenol	208968	Acenaphthylene
98953	Nitrobenzene	218019	Chrysene
99092	3-Nitroaniline	360689	3B-Coprostanol
100016	4-Nitroaniline	483658	Retene
100027	4-Nitrophenol	534521	4,6-Dinitro-2-Methylphenol
100516	Benzyl Alcohol	541731	1,3-Dichlorobenzene
101553	4-Bromophenyl-Phenylether	581420	2,6-Dimethylnaphthalene
104405	Phenol, 4-Nonyl-	606202	2,6-Dinitrotoluene
105679	2,4-Dimethylphenol	621647	N-Nitroso-Di-N-Propylamine
106445	4-Methylphenol	832699	1-Methylphenanthrene
106467	1,4-Dichlorobenzene	2245387	1,6,7-Trimethylnaphthalene
106478	4-Chloroaniline	2531842	2-Methylphenanthrene
108601	2,2'-Oxybis[1-chloropropane]	7005723	4-Chlorophenyl-Phenylether
108952	Phenol		
110861	Pyridine	**Polychlorinated Biphenyls**	
111444	Bis(2-Chloroethyl)Ether	11096825	PCB - 1260
111911	Bis(2-Chloroethoxy)Methane	11097691	PCB - 1254
117817	Bis(2-Ethylhexyl) Phthalate	11104282	PCB - 1221
117840	Di-N-Octyl Phthalate	11141165	PCB - 1232
118741	Hexachlorobenzene	12672296	PCB - 1248
120127	Anthracene	12674112	PCB - 1016
120821	1,2,4-Trichlorobenzene	53469219	PCB - 1242

Appendix C. Target Chemicals (continued)

CAS No.	Chemical Name	CAS No.	Chemical Name
Nitrogen-Containing Pesticides		**Nitrogen-Containing Pesticides**	
63252	Carbaryl	26399360	Profluralin
101213	Chlorpropham	27314132	Norflurazon
113484	MGK264	34014181	Tebuthiuron
122349	Simazine	40487421	Pendimethalin
122394	Diphenylamine	42874033	Oxyfluorfen
139402	Propazine	43121433	Triadimefon
314409	Bromacil	51218452	Metolachlor
330541	Diuron	51235042	Hexazinone
759944	Eptam	55283686	Ethalfluralin (Sonalan)
834128	Ametryn	57837191	Metalaxyl
886500	Terbutryn (Igran)	59756604	Fluridone
957517	Diphenamid	60168889	Fenarimol
1114712	Pebulate		
1134232	Cycloate	**Organophosphorus Pesticides**	
1194656	Dichlobenil	55389	Fenthion
1582098	Treflan (Trifluralin)	56382	Parathion
1610179	Atraton	56724	Coumaphos
1610180	Prometon (Pramitol 5p)	60515	Dimethoate
1861401	Benefin	62737	Dichlorvos (DDVP)
1897456	Chlorothalonil (Daconil)	78342	Dioxathion
1912249	Atrazine	78488	Tribufos (DEF)
1918167	Propachlor (Ramrod)	86500	Azinphos (Guthion)
1929777	Vernolate	115902	Fensulfothion
2008415	Butylate	121755	Malathion
2212671	Molinate	122145	Fenitrothion
2303164	Di-allate (Avadex)	126750	Demeton-S
2303175	Triallate	150505	Merphos (1 & 2)
5234684	Carboxin	297994	Phosphamidan
5902512	Terbacil	298000	Methyl Parathion
7287196	Prometryn	298022	Phorate
15299997	Napropamide	298033	Demeton-O
15972608	Alachlor	298044	Disulfoton (Di-Syston)
21087649	Metribuzin	299843	Ronnel
21725462	Cyanazine	333415	Diazinon
23184669	Butachlor	563122	Ethion
23950585	Pronamide (Kerb)	732116	Imidan

Appendix C. Target Chemicals (continued)

CAS No.	Chemical Name
Organophosphorus Pesticides	
786196	Carbophenothion
944229	Fonofos
950356	Methyl Paraoxon
961115	Tetrachlorvinphos (Gardona)
2104645	EPN
2652719	Azinphos Ethyl
2921882	Chlorpyriphos
3383968	Abate (Temephos)
3689245	Sulfotepp
5598130	Methyl Chlorpyrifos
7786347	Mevinphos
13194484	Ethoprop
22224926	Fenamiphos
31218834	Propetamphos
35400432	Bolstar (Sulprofos)
Organochlorine Pesticides	
50293	4,4'-DDT
53190	2,4'-DDD
58899	Gamma-BHC (Lindane)
60571	Dieldrin
72208	Endrin
72435	Methoxychlor
72548	4,4'-DDD
72559	4,4'-DDE
76448	Heptachlor
115322	Kelthane
133062	Captan
309002	Aldrin
319846	Alpha-BHC
319857	Beta-BHC
319868	Delta-BHC
789026	2,4'-DDT
959988	Endosulfan I
1022226	DDMU
Organochlorine Pesticides	
1024573	Heptachlor Epoxide
1031078	Endosulfan Sulfate
2385855	Mirex
2425061	Captafol
3424826	2,4'-DDE
5103719	Cis-Chlordane (Alpha-Chlordane)
5103731	Cis-Nonachlor
5103742	Trans-Chlordane (Gamma)
7421934	Endrin Aldehyde
8001352	Toxaphene
27304138	Oxychlordane
33213659	Endosulfan II
39765805	Trans-Nonachlor
53494705	Endrin Ketone
56534022	Alpha-Chlordene
5653404G	Gamma-Chlordene
Acid Herbicides	
51365	3,5-Dichlorobenzoic Acid
58902	2,3,4,6-Tetrachlorophenol
87865	Pentachlorophenol
88062	2,4,6-Trichlorophenol
88857	Dinoseb
93652	MCPP (Mecoprop)
93721	2,4,5-TP (Silvex)
93765	2,4,5-T
93801	2,4,5-TB
94746	MCPA
94757	2,4-D
94826	2,4-DB
95954	2,4,5-Trichlorophenol
100027	4-Nitrophenol
120365	Dichlorprop
1689834	Ioxynil
1689845	Bromoxynil

Appendix C. Target Chemicals (continued)

CAS No.	Chemical Name	CAS No.	Chemical Name
Acid Herbicides		**Polychlorinated Dibenzo-p-dioxins**	
1861321	Dacthal (DCPA)	1746016	2,3,7,8-TCDD
1918009	Dicamba I	40321764	1,2,3,7,8-PeCDD
1918021	Picloram	39227286	1,2,3,4,7,8-HxCDD
4901513	2,3,4,5-Tetrachlorophenol	57652857	1,2,3,6,7,8-HxCDD
25057890	Bentazon	19408743	1,2,3,7,8,9-HxCDD
51338273	Diclofop-Methyl	35822469	1,2,3,4,6,7,8-HpCDD
55335063	Trichlopyr	3268879	OCDD
62476599	Acifluorfen (Blazer)		
Carbamates		**Polychlorinated Dibenzofurans**	
63252	Carbaryl	51207319	2,3,7,8-TCDF
90153	1-Naphthol	57117416	1,2,3,7,8-PeCDF
114261	Baygon (Propoxur)	57117314	2,3,4,7,8-PeCDF
116063	Aldicarb	70648269	1,2,3,4,7,8-HxCDF
1563662	Carbofuran	57117449	1,2,3,6,7,8-HxCDF
1646873	Aldicarb Sulfoxide	60851345	2,3,4,6,7,8-HxCDF
1646884	Aldicarb Sulfone	72918219	1,2,3,7,8,9-HxCDF
2032657	Methiocarb	67562394	1,2,3,4,6,7,8-HpCDF
16655826	3-Hydroxycarbofuran	55673897	1,2,3,4,7,8,9-HpCDF
16752775	Methomyl	39001020	OCDF
23135220	Oxamyl (Vydate)		
Butyltins			
1461252	Tetrabutyltin		
56573854	Tributyltin		
1002535	Dibutyltin		
78763549	Monobutyltin		

Appendix D

Ecology Water Quality Criteria Spreadsheet (partial)

Prepared by D. Nunnallee, G. Shervey, G. Bailey

	PRIOR	Water Quality Criteria				Human Health		
	ITY	Fresh		Marine		Criteria		Source and
Pollutant, CAS No. & Application Ref. No.	PLTNT?	acute	chronic	acute	chronic	Fresh	Marine	Comments
WATER QUALITY CRITERIA (in ug/L unless otherwise noted)								
	PRIOR	Water Quality Criteria				Human Health		
	ITY	Fresh		Marine		Criteria		Source and
Pollutant, CAS No. & Application Ref. No.	PLTNT?	acute	chronic	acute	chronic	Fresh	Marine	Comments
ENTER HARDNESS>>>>>>>>>	100							
ACENAPTHENE 83329 1B	Y	1,700.*	520.*	970.*	710*			Gold Book
ACROLEIN 107028 1V	Y	68.*	21.*	55.*		320	780	NTR, Gold Book
ACRYLONITRILE 107131 2V	Y	7,550.*	2,600.*			0.059	0.66	Gold Book, NTR - HH
ALKALINITY	N		20,000.					Gold Book
ALDRIN 309002 1P	Y	2.50	0.0019	0.71	0.0019	0.00013	0.00014	WAC 173-201A, NTR
ALUMINUM	N	750	87					EPA 440/5-86-008
AMMONIA unionized -see seperate spreadsheets for FW criteria	N			233	35			WAC 173-201A
ANTHRACENE 120127 3B	Y					9600	110000	NTR
ANTIMONY (INORGANIC) 7440360 1M	Y	9000	1600			14	4300	NTR - HH
ARSENIC (dissolved) 7440382 2M	Y	360	190	69	36			WAC 173-201A
ARSENIC (inorganic)	Y					0.018	0.14	NTR
ARSENIC(PENT)	Y	850	48	2319	13			Gold Book
ARSENIC(TRI)	Y	360	190	69	36			Gold Book
ASBESTOS 1332214	Y					7000,000 fibers/L		NTR-HH
BACTERIA	N	see document						WAC 173-201A
BARIUM	N		EPA recommends 1 mg/L for drinking water					Gold Book
BENZENE 71432 3V	Y	5300		5100	700	1.20	71	Gold Book, NTR - HH
BENZIDINE 92875 4B	Y	2500				0.00012	0.00054	Gold Book, NTR - HH
BENZO(a)ANTHRACENE 56553 5B	Y					0.0028	0.031	NTR
BENZO(a)PYRENE 50328 6B	Y					0.0028	0.031	NTR
BENZO(b)FLUORANTHENE 205992 7B	Y					0.0028	0.031	NTR
BENZO(k) FLUORANTHENE 207089 9B	Y					0.0028	0.031	NTR
BERYLLIUM 7440417 3M	Y	130	5.30					Gold Book
BHC - ALPHA 319846 2P	Y	100		0.34		0.0039	0.013	Gold Book, NTR - HH
BHC - BETA 319857 3P	Y	100		0.34		0.014	0.046	Gold Book, NTR - HH
BHC - GAMMA 58899 4P (Lindane)	N	2	0.08	0.16		0.0190	0.063	173-201A, NTR - HH
BHC - DELTA 319868 5P	Y							no criteria available
BIS(2-CHLOROETHYL)ETHER 111444 11B	Y					0.031	1.4	NTR
BIS(2 CHLOROISOPROPYL)ETHER 108601 102601 12B	Y					1400	170000	NTR
BIS(2-ETHYLHEXYL) PHTHALATE 117817 13B	Y	940	3	2944	3.40	1.8	5.9	Gold Book, NTR

	PRIOR ITY	Water Quality Criteria				Human Health Criteria		
		Fresh		Marine				
Pollutant, CAS No. & Application Ref. No.	PLTNT?	acute	chronic	acute	chronic	Fresh	Marine	Source and Comments
BROMOFORM 75252 5V	Y					4.3	360	NTR
CADMIUM - 7440439 4M Hardness dependent	Y	3.70	1.03	42.00	9.3			WAC 173-201A
Based on hardness in next column	100							
CARBON TETRACHLORIDE 56235 6V	Y	35200		50000		0.25	4.40	Gold Book, NTR - HH
CHLOROBENZENE 108907 7V	Y					680	21000	NTR
CHLORDANE 57749 6P	Y	2.4	0.0043	0.09	0.004	0.00057	0.00059	WAC 173-201A, NTR
CHLORODIBROMOMETHANE 124481 8V	Y					0.41	34	NTR
CHLORIDE (dissolved) in mg/L		860	230					SEE WAC 173-201A FOOTNOTES
2-CHLORONAPTHALENE 91587 16B	Y	1600		7.50				Gold Book
CHLORINE	N	19	11	13	7.50			WAC 173-201A
CHLOROALKYL ETHERS	Y	238000						Gold Book
CHLOROETHYL ETHER (BIS - 2) 111444	Y					0.031	1.40	NTR
CHLOROFORM 67663 11V	Y	28900	1240			5.70	470	Gold Book, NTR - HH
CHLOROISOPROPYL ETHER (BIS-2) 108601	Y					1400	170000	NTR
CHLOROMETHYL ETHER (BIS)	N					0.03	1.36	Gold Book
CHLOROPHENOL 2 95578 1A	Y	4380	2000					Gold Book
CHLOROPHENOL 4	N			29700				Gold Book
CHLOROPHENOXY HERBICIDES(2,4,5-TP)	N		10 in drinking water					Gold Book
CHLOROPHENOXY HERBICIDES(2,4-D)	N		100 in drinking water					Gold Book
CHLORPYRIFOS	N	0.083	0.041	0.011	0.0056			WAC 173-201A
CHLORO-4METHYL-3 PHENOL	N	30						Gold Book
CHROMIUM(HEX) 18540299	Y	15	10	1100	50			WAC 173-201A
CHROMIUM(TRI) -7440473 5M Hardness dependent	N	548.74	178.00	*10300*	NA			WAC 173-201A, EXCEPT MARINE
Based on hardness in next column	100							
CHRYSENE 218019 18B	Y					0.0028	0.031	NTR
COLOR	N	narrative statement see document						WAC 173-201A
COPPER - 744058 6M Hardness dependent	Y	17.02	11.35	4.80	3.10			WAC 173-201A
Based on hardness in next column	100							
CYANIDE 57125 14M	Y	22	5.20	1.00	1.00	700	220000	WAC 173-201A, NTR
DDT 50293 7P	Y	1.10	0.001	0.13	0.001	0.00059	0.00059	WAC 173-201A, NTR
DDT METABOLITE (DDE) 72559 8P	Y	1.10	0.001	0.13	0.001	0.00059	0.00059	WAC 173-201A, NTR
DDT METABOLITE (DDD) 72548 9P	Y	1.10	0.001	0.13	0.001	0.00083	0.00084	WAC 173-201A, NTR
DEMETON	Y		0.10		0.10			Gold Book
DIBENZO(a,h)ANTHRACENE 53703 19B	Y					0.0028	0.031	NTR
DIBUTYLPHTHALATE 84742	Y	940	3	2944	3.40	2700	12000	Gold Book, NTR - HH
1,2 DICHLOROBENZENE 95501 20B	Y	1120	763	1970		2700	17000	NTR - HH

Pollutant, CAS No. & Application Ref. No.	PRIORITY PLTNT?	Water Quality Criteria Fresh acute	Fresh chronic	Marine acute	Marine chronic	Human Health Criteria Fresh	Human Health Criteria Marine	Source and Comments
1,3 DICHLOROBENZENE 541731 21B	Y	1120	763	1970		400	2600	NTR - HH
1,4 DICHLOROBENZENE 106467 22B	Y	1120	763	1970		400	2600	NTR - HH
3,3 DICHLOROBENZIDINE 91941 23B	Y					0.04	0.077	NTR
DICHLOROBROMOMETHANE 75274 12V	Y					0.27	22	NTR
DICHLOROETHANE 1,2 107062 15V	Y	118000	20000	113000		0.38	99	Gold Book, NTR - HH
1,1 DICHLOROETHYLENE 75354 16V	Y	11600		224000		0.057	3.20	Gold Book, NTR - HH
DICHLOROPHENOL 2,4 1208312 2A	N	2020	365			93.00	790.00	NTR - HH
DICHLOROPROPANE	Y	23000	5700	10300	3040			Gold Book
DICHLOROPROPENE	Y	6060	244	790				Gold Book
1,3 -DICHLOROPROPYLENE 542756 18V	Y					10	1700	NTR
DIELDRIN 60571 10P	Y	2.50	0.0019	0.71	0.0019	0.00014	0.00014	WAC 173-201A, NTR
DIETHYLPHTHALATE 84662 24B	Y	940	3	2944	3.40	23000	120000	Gold Book, NTR - HH
DIMETHYLPHENOL 2,4 105679	Y	2120						
DIMETHYLPHTHALATE 131113 25B	Y	940	3	2944	3.40	313000	2900000	Gold Book, NTR - HH
DI-n-BUTYL PHTHALATE 84742 26B	Y					2700	12000	NTR
2-METHYL-4,6 -DINITROPHENOL 534521 4A	Y					13.4	765	NTR
2,4-DINITROPHENOL 51285 5A	Y					70.0	14000	NTR
DINITROTOLUENE 2,4 121142 27B	Y	330	230	590	370	0.11	9.10	Gold Book, NTR - HH
DINITROTOLUENE 2,6 606202 28B	Y	330	230	590	370			Gold Book
DINITRO-O-CRESOL 2,4	Y					13.40	765.00	Gold Book
DIOXIN (2,3,7,8-TCDD) 1746016	Y	0.01	0.00001			0.000000013	0.000000014	Gold Book, NTR - HH
DIPHENYLHYDRAZINE 1,2 122667 30B	Y	270				0.04	0.54	Gold Book, NTR - HH
DI-2-ETHYLHEXYLPHTHALATE 117817	Y	940	3	2944	3.40	1.8	5.9	WQC based on Gold Book values f
ENDOSULFAN a 959988 11P, b 33213659 12P	Y	0.22	0.056	0.034	0.0087	0.93	2.0	WAC 173-201A, NTR
ENDOSULFAN SULFATE 1031078 13P	Y					0.93	2.0	NTR
ENDRIN 72208 14P	Y	0.18	0.0023	0.037	0.0023	0.76	0.81	WAC 173-201A, NTR
ENDRIN ALDEHYDE 7421934 15P	Y					0.76	0.81	NTR
ETHYLBENZENE 100414 19V	Y	32000		430		3100	29000	Gold Book, NTR - HH
FLUORANTHENE 206440 31B	Y	3980		40	16	300	370	Gold Book, NTR - HH
FLUORENE 86737 32B	Y					1300	14000	NTR
GASSES, TOTAL DISSOLVED	N	see WAC 173-201A and the Gold Book						
GUTHION	N		0.01		0.01			Gold Book
HALOETHERS	Y	380	122					Gold Book
HALOMETHANES	Y	11000		12000	6400			Gold Book
HEPTACHLOR 76448 16P	Y	0.52	0.0038	0.0530	0.0036	0.00021	0.00021	WAC 173-201A, NTR
HEPTACHLOR EPOXIDE 1024573 17P	Y	0.52	0.0038	0.0530	0.0036	0.00010	0.00011	WAC 173-201A, NTR

Pollutant, CAS No. & Application Ref. No.	PRIORITY PLTNT?	Water Quality Criteria Fresh acute	Fresh chronic	Marine acute	Marine chronic	Human Health Criteria Fresh	Human Health Criteria Marine	Source and Comments
HEXACHLOROBENZENE 118741 33B	Y					0.00075	0.00077	NTR - HH
HEXACHLOROBUTADIENE 87683 34B	Y	90	9.30	32		0.44	50	NTR - HH
HEXACHLOROCYCLOHEXANE-ALPHA 319846 2P	Y					0.0039	0.013	NTR
HEXACHLOROCYCLOHEXANE-BETA 319857 3P	Y					0.014	0.046	NTR
HEXACHLOROCYCLOHEXANE-GAMMA (lindane) 58899 4P	Y	2	0.08	0.16		0.019	0.063	WAC 173-201A, NTR
HEXACHLOROCYCLOHEXANE-DELTA 319868 5P	Y							no criteria available
HEXACHLOROCYCLOPENTADIENE 77474 35B	Y	7	5.20	7.0		240	17000	Gold Book, NTR - HH
HEXACHLOROETHANE 67721 36B	N	980	540	940		1.90	8.90	Gold Book, NTR - HH
INDENO(1,2,3-cd)PYRENE 193395 37B	Y					0.0028	0.031	NTR
IRON	N		1000					Gold Book
ISOPHORONE 78591	Y	117000		12900		8.40	600	Gold Book, NTR - HH
LEAD - 7439921 7M Dependent on hardness	Y	64.58	2.52	210.00	8.10			WAC 173-201A,
Based on hardness in next column [c]	100							
MALATHION	N		0.10		0.10			Gold Book
MANGANESE	N		See Gold Book					
METHYL BROMIDE 74839 20V	Y					48	4000	NTR
METHYLENE CHLORIDE 75092 22V	Y					4.7	1600	NTR
MERCURY 7439976 8M	Y	2.10	0.012	1.80	0.0250	0.14	0.15	WAC 173-201A, NTR - HH
METHOXYCHLOR	N		0.03		0.03			Gold Book
MIREX	N		0.001		0.001			Gold Book
MONOCHLOROBENZENE 108907	Y		See Chlorobenzene					
NAPHTHALENE 91203 39B	Y	2300	620	2350				Gold Book
NICKEL - 7440020 9M - Dependent on hardness	Y	1415.41	157.19	74.00	8.20	610	4600	WAC 173-201A, NTR
Based on hardness in next column	100							
NITRATES	N		See Gold Book					
NITROBENZENE 98953 40B	Y	27000		6680		17	1900	Gold Book, NTR - HH
NITROPHENOL	Y	230	150.00	4850				Gold Book
NITROSAMINES	Y	5850		3300000				Gold Book
NITROSODIBUTYLAMINE N	Y		See Gold Book					
NITROSODIETHYLAMINE N	Y		See Gold Book					
NITROSODIMETHYLAMINE N 62759 41B	Y					0.00069	8.10	NTR
NITROSODIPHENYLAMINE N 86306 43B	Y					5	16	NTR
NITROSOPYRROLIDINE N	Y		See Gold Book					
OIL AND GREASE	N		See Gold Book and Ecology WQ Technical Guidance					
OXYGEN DISSOLVED	N		See WAC 173-201A					
PARATHION	N	0.065	0.013					WAC 173-201A,

	PRIOR ITY	Water Quality Criteria				Human Health Criteria		
		Fresh		Marine				Source and
Pollutant, CAS No. & Application Ref. No.	PLTNT?	acute	chronic	acute	chronic	Fresh	Marine	Comments
Polychlorinated Biphenyls (PCB's) 53469219, 11097691, 1104	Y	2	0.014	10	0.03	0.000044	0.000045	WAC 173-201A, NTR
PENTACHLOROBENZENE	N		See Gold Book					
PENTACHLOROPHENOL 87865 8A (pH dependent in	Y	9.07	5.73	13.	7.90	0.28	8.20	WAC 173-201A, NTR
fresh water) Enter pH in next cell>>>>>>>>	7.00							
pH	N		6.5 - 8.5		7.0 - 8.5			WAC 173-201A,
PHENOL 108952 10A	Y	10200	2560	5800		21000	4600000	Gold Book, NTR - HH
PHOSPHORUS-ELEMENTAL	N				0.10			Gold Book
POLYNUCLEAR AROMATIC HYDROCARBONS	Y			300				Gold Book
PYRENE 129000 45B	Y					960	11000	NTR
SELENIUM 7782492 10M	Y	20	5	290	71			WAC 173-201A,
SILVER - 7740224 11M dependent on hardness.	Y	3.45	NA	1.90	NA			SEE WAC 173-201A, acute level
Based on hardness in next column	100							not to be exceeded at any time
SOLIDS,DISSOLVED AND SALINITY	N		See Gold Book					
SOLIDS,SUSPENDED AND TURBIDITY	N		See Gold Book and WAC 173-201A					Gold Book
TETRACHLORINATED ETHANES	Y	9320						Gold Book
TETRACHLOROBENZENE 1,2,4,5	Y		See Gold Book					
TETRACHLOROETHANE 1,1,2,2 79345 23V	Y		2400	9020		0.17	11.00	Gold Book, NTR - HH
TETRACHLOROETHANE	Y	9320						Gold Book
TETRACHLOROETHYLENE 127184 24V	Y	5280	840	10200	450	0.80	8.85	Gold Book, NTR - HH
TETRACHLOROPHENOL 2,3,5,6	Y			440				Gold Book
THALLIUM 7440280 12M	Y	1400	40	2130		1.70	6.30	Gold Book, NTR - HH
TOLUENE 108883 25V	Y	17500		6300	5000	6800	200000	Gold Book, NTR - HH
TOXAPHENE 8001352 25P	Y	0.73	0.0002	0.21	0.0002	0.00073	0.00075	WAC 173-201A, NTR
TRICHLORINATED ETHANES	Y	18000						Gold Book
TRICHLOROETHANE 1,1,1 71556 27V	Y			31200				Gold Book
TRICHLOROETHANE 1,1,2 79005 28V	Y		9400			0.60	42.00	Gold Book, NTR - HH
TRICHLOROETHYLENE 79016 29V	Y	45000	21900	2000		2.70	81.00	Gold Book, NTR - HH
TRICHLOROPHENOL 2,4,5	N		See Gold Book					
TRICHLOROPHENOL 2,4,6 88062 11A	Y		970			2.10	6.50	Gold Book, NTR - HH
VINYL CHLORIDE 75014 31V	Y					2	525	NTR
ZINC- 7440666 13M hardness dependent	Y	114.45	104.51	90.00	81.00			WAC 173-201A,
Based on hardness in next column	100							
* = INSUFFICIENT DATA TO DEVELOP CRITERIA VALUE								
PRESENTED IS THE L.O.E.L- LOWEST OBSERVED								

Appendix E

Tentatively Identified Compounds

(No TICs identified in sample no. 32800)

Manchester Environmental Laboratory

Department of Ecology

Analysis Report for

Volatile Organic Analysis + all TIC's

Project Name: Whitmarsh Landfill **LIMS Project ID:** 1831-98

Sample: 98248005 **Date Received:** 06/12/98 **Method:** SW8260
Field ID: N SEEP **Matrix:** Water
Project Officer: Art Johnson **Date Analyzed:** 06/15/98 **Units:** ug/L

Tentatively Identified Compounds

CAS Number	Analyte Description	Result	Qualifier
622968	*Benzene, 1-ethyl-4-methyl-*	.6	NJ
767588	*Indan, 1-methyl-*	.35	NJ
27133933	*2,3-Dihydro-1-methylindene*	.3	NJ
1879169	*Benzene, 1-methoxy-4-(methylthio)-*	.94	NJ

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Manchester Environmental Laboratory

Department of Ecology

Analysis Report for

Volatile Organic Analysis + all TIC's

Project Name: Whitmarsh Landfill **LIMS Project ID:** 1831-98

Sample: 98248006 **Date Received:** 06/12/98 **Method:** SW8260
Field ID: S SEEP **Matrix:** Water
Project Officer: Art Johnson **Date Analyzed:** 06/15/98 **Units:** ug/L

Tentatively Identified Compounds

CAS Number	Analyte Description	Result	Qualifier
4127473	*Cyclopropane, 1,1,2,2-tetramethyl-*	.46	NJ
625809	*Diisopropyl sulfide*	1.8	NJ
611143	*Benzene, 1-ethyl-2-methyl-*	.8	NJ
93538	*Benzeneacetaldehyde, .alpha.-methyl-*	.58	NJ
25155151	*Benzene, methyl(1-methylethyl)-*	.69	NJ
27133933	*2,3-Dihydro-1-methylindene*	.75	NJ
934805	*Benzene, 4-ethyl-1,2-dimethyl-*	.74	NJ
1587048	*Benzene, 1-methyl-2-(2-propenyl)-*	1	NJ

Authorized By: [signature] Release Date: 7/21/98

Manchester Environmental Laboratory

Department of Ecology

Analysis Report for

BNA FOR NOAA

Project Name: Whitmarsh Landfill | **LIMS Project ID:** 1831-98

Sample: 98248005 | **Date Received:** 06/12/98 | **Method:** SW8270
Field ID: N SEEP | **Date Prepared:** 06/16/98 | **Matrix:** Water
Project Officer: Art Johnson | **Date Analyzed:** 07/14/98 | **Units:** ug/L

Tentatively Identified Compounds

CAS Number	Analyte Description	Result	Qualifier
108985	*Benzenethiol*	1.2	NJ
526738	*Benzene, 1,2,3-trimethyl-*	.83	NJ
108678	*1,3,5-Trimethylbenzene*	.83	NJ
95363	*1,2,4-Trimethylbenzene*	.86	NJ
496117	*Indane*	.76	NJ
576261	*Phenol, 2,6-dimethyl-*	7.8	NJ
95658	*Phenol, 3,4-dimethyl-*	.43	NJ
95874	*Phenol, 2,5-dimethyl-*	1	NJ
2416946	*Phenol, 2,3,6-trimethyl-*	4.8	NJ
1687645	*Phenol, 2-ethyl-6-methyl-*	4.3	NJ
1123940	*Phenol, 4-ethyl-3-methyl-*	12	NJ
585342	*Phenol, m-tert-butyl-*	3.6	NJ
527548	*Phenol, 3,4,5-trimethyl-*	14	NJ
1197348	*Phenol, 3,5-diethyl-*	5.5	NJ
2219785	*Phenol, 2-ethyl-4,5-dimethyl-*	2.4	NJ
937304	*Ethanone, 1-(4-ethylphenyl)-*	2.5	NJ
20294320	*6-Methyl-4-indanol*	.86	NJ
527559	*1,3-Benzenediol, 4,5-dimethyl-*	2.6	NJ
4076408	*Benzo[c]phenanthrene, 4-methyl-*	4.4	NJ
90153	*1-Naphthol*	4.8	NJ
2498773	*Benz[a]anthracene, 1-methyl-*	7.4	NJ
2498751	*Benz[a]anthracene, 3-methyl-*	5.6	NJ
6325684	*Benzoic acid, o-(o-tolyloxy)-*	12	NJ
137177	*Benzenamine, 2,4,5-trimethyl-*	5.1	NJ
*3001950	*C1-Naphthalenes*	0.91	NJ
*3001951	*C2 -Naphthalenes*	0.92	NJ
*3001954	*C1-Fluorenes*	0.12	NJ
*3001955	*C2-Fluorenes*	0.12	NJ
*3001952	*C3 -Naphthalenes*	.62	NJ
*3001956	*C3-Fluorenes*	.12	U
*3001953	*C4 -Naphthalenes*	.12	U
*3001957	*C1-Dibenzothiophenes*	.11	NJ
*3001960	*C1-Phenanthrenes/Anthracenes*	.18	NJ
*3001961	*C2-Phenanthrenes/Anthracenes*	.12	U
*3001958	*C2-Dibenzothiophenes*	1090	NJ

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Manchester Environmental Laboratory

Department of Ecology

Analysis Report for

BNA FOR NOAA

Project Name: Whitmarsh Landfill **LIMS Project ID:** 1831-98

Sample: 98248005 **Date Received:** 06/12/98 **Method:** SW8270
Field ID: N SEEP **Date Prepared:** 06/16/98 **Matrix:** Water
Project Officer: Art Johnson **Date Analyzed:** 07/14/98 **Units:** ug/L

Tentatively Identified Compounds (continued)

CAS Number	Analyte Description	Result	Qualifier
***3001959**	***C3-Dibenzothiophenes***	**.12**	**U**
***3001962**	***C3-Phenanthrenes/Anthracenes***	**.12**	**U**
***3001963**	***C4-Phenanthrenes/Anthracenes***	**.12**	**U**
***3001964**	***C1-Fluoranthene/Pyrene***	**28**	**NJ**
***3001965**	***C1-Chrysenes***	**.12**	**U**
***3001966**	***C2-Chrysenes***	**.12**	**U**
***3001967**	***C3-Chrysenes***	**.12**	**U**
***3001968**	***C4-Chrysenes***	**.12**	**U**

Authorized By: [signature] Release Date: 7/23/98

Manchester Environmental Laboratory

Department of Ecology

Analysis Report for

BNA FOR NOAA

Project Name: Whitmarsh Landfill **LIMS Project ID:** 1831-98

Sample: 98248006 **Date Received:** 06/12/98 **Method:** SW8270
Field ID: S SEEP **Date Prepared:** 06/16/98 **Matrix:** Water
Project Officer: Art Johnson **Date Analyzed:** 07/14/98 **Units:** ug/L

Tentatively Identified Compounds

CAS Number	Analyte Description	Result	Qualifier
625809	*Diisopropyl sulfide*	.59	NJ
108907	*Chlorobenzene*	.29	NJ
108383	*Benzene, 1,3-dimethyl-*	.24	NJ
95476	*o-Xylene*	.18	NJ
95147	*1H-Benzotriazole*	.17	NJ
108985	*Benzenethiol*	.1	NJ
74630914	*Hexane, 3-methoxy-3-methyl-*	.75	NJ
496117	*Indane*	1.1	NJ
1074175	*Benzene, 1-methyl-2-propyl-*	.21	NJ
99876	*p-Isopropyltoluene*	.73	NJ
767588	*Indan, 1-methyl-*	.91	NJ
27133933	*2,3-Dihydro-1-methylindene*	.91	NJ
539800	*2,4,6-Cycloheptatrien-1-one*	4.6	NJ
697825	*Phenol, 2,3,5-trimethyl-*	.65	NJ
527606	*Phenol, 2,4,6-trimethyl-*	.31	NJ
507700	*Borneol*	.88	NJ
88186	*Phenol, 2-(1,1-dimethylethyl)-*	.5	NJ
585342	*Phenol, m-tert-butyl-*	8.8	NJ
527548	*Phenol, 3,4,5-trimethyl-*	1.1	NJ
719222	*2,5-Cyclohexadiene-1,4-dione, 2,6-bis(1,1-dimethyle*	.67	NJ
934349	*2(3H)-Benzothiazolone*	7.6	NJ
1421494	*Benzoic acid, 3,5-bis(1,1-dimethylethyl)-4-hydroxy-*	.94	NJ
80057	*Phenol, 4,4'-(1-methylethylidene)bis-*	1.4	NJ
*3001950	*C1-Naphthalenes*	.83	NJ
*3001951	*C2 -Naphthalenes*	.95	NJ
*3001954	*C1-Fluorenes*	.12	U
*3001955	*C2-Fluorenes*	.12	U
*3001952	*C3 -Naphthalenes*	.51	NJ
*3001956	*C3-Fluorenes*	.12	U
*3001953	*C4 -Naphthalenes*	.12	U
*3001957	*C1-Dibenzothiophenes*	.12	U
*3001960	*C1-Phenanthrenes/Anthracenes*	.099	NJ
*3001961	*C2-Phenanthrenes/Anthracenes*	.12	U
*3001958	*C2-Dibenzothiophenes*	.12	U
*3001959	*C3-Dibenzothiophenes*	.12	U

Authorized By: [illegible] Release Date: 7/23/98

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Analysis Report for

BNA FOR NOAA

Project Name: Whitmarsh Landfill **LIMS Project ID:** 1831-98

Sample: 98248006 **Date Received:** 06/12/98 **Method:** SW8270
Field ID: S SEEP **Date Prepared:** 06/16/98 **Matrix:** Water
Project Officer: Art Johnson **Date Analyzed:** 07/14/98 **Units:** ug/L

Tentatively Identified Compounds (continued)

CAS Number	Analyte Description	Result	Qualifier
*3001962	*C3-Phenanthrenes/Anthracenes*	.12	NJ
*3001963	*C4-Phenanthrenes/Anthracenes*	.12	U
*3001964	*C1-Fluoranthene/Pyrene*	.12	U
*3001965	*C1-Chrysenes*	.12	U
*3001966	*C2-Chrysenes*	.12	U
*3001967	*C3-Chrysenes*	.12	U
*3001968	*C4-Chrysenes*	.12	U

Authorized By: [signature] Release Date: 7/23/98

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Department of Ecology

Analysis Report for

BNA FOR NOAA

Project Name: Whitmarsh Landfill **LIMS Project ID:** 1831-98

Sample: 98248007 **Date Received:** 06/12/98 **Method:** SW8270
Field ID: N SED **Date Prepared:** 06/18/98 **Matrix:** Sediment/Soil
Project Officer: Art Johnson **Date Analyzed:** 07/15/98 **Units:** ug/Kg dw

Tentatively Identified Compounds

CAS Number	Analyte Description	Result	Qualifier
107868	*2-Butenal, 3-methyl-*	3770	NJ
141797	*3-Penten-2-one, 4-methyl-*	42600	NJ
100527	*Benzaldehyde*	487	NJ
108985	*Benzenethiol*	1290	NJ
98862	*Acetophenone*	338	NJ
100538	*Benzenemethanethiol*	8280	NJ
118729	*2,6-Dimethylthiophenol*	520	NJ
18800538	*3,4-Dimethylthiophenol*	576	NJ
69727	*Salicylic Acid*	517	NJ
1574409	*3-Penten-1-yne, (Z)-*	602	NJ
112050	*Nonanoic acid*	602	NJ
2004695	*3-Penten-1-yne, (E)-*	602	NJ
98920	*Niacinamide*	1940	NJ
1759280	*Thiazole, 5-ethenyl-4-methyl-*	767	NJ
638539	*Tridecanoic acid*	1420	NJ
629970	*Docosane*	21100	NJ
544638	*Tetradecanoic acid*	2720	NJ
150867	*Phytol*	24800	NJ
297030	*Cyclotetracosane*	3810	NJ
80977	*Cholestanol*	4560	NJ
55514971	*Ergosta-14,22-dien-3-ol, (3.beta.,5.alpha.,22E)-*	4560	NJ
17472785	*Ergosta-5,22-dien-3-ol, (3.beta.,22E,24S*	6120	NJ
26047314	*Ergost-7-en-3-ol, (3.beta.)-*	3710	NJ
83476	*.gamma.-Sitosterol*	8990	NJ
*3001950	*C1-Naphthalenes*	174	NJ
*3001951	*C2 -Naphthalenes*	503	NJ
*3001954	*C1-Fluorenes*	179	U
*3001955	*C2-Fluorenes*	179	U
*3001952	*C3 -Naphthalenes*	179	U
*3001956	*C3-Fluorenes*	179	U
*3001953	*C4 -Naphthalenes*	179	U
*3001957	*C1-Dibenzothiophenes*	179	U
*3001960	*C1-Phenanthrenes/Anthracenes*	671	NJ
*3001961	*C2-Phenanthrenes/Anthracenes*	179	U
*3001958	*C2-Dibenzothiophenes*	179	U

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Analysis Report for

BNA FOR NOAA

Project Name: Whitmarsh Landfill **LIMS Project ID:** 1831-98

Sample: 98248007 **Date Received:** 06/12/98 **Method:** SW8270
Field ID: N SED **Date Prepared:** 06/18/98 **Matrix:** Sediment/Soil
Project Officer: Art Johnson **Date Analyzed:** 07/15/98 **Units:** ug/Kg dw

Tentatively Identified Compounds (continued)

CAS Number	Analyte Description	Result	Qualifier
*3001959	*C3-Dibenzothiophenes*	179	U
*3001962	*C3-Phenanthrenes/Anthracenes*	179	U
*3001963	*C4-Phenanthrenes/Anthracenes*	179	U
*3001964	*C1-Fluoranthene/Pyrene*	143	NJ
*3001965	*C1-Chrysenes*	131	NJ
*3001966	*C2-Chrysenes*	179	U
*3001967	*C3-Chrysenes*	179	U
*3001968	*C4-Chrysenes*	179	U

Authorized By: ________ Release Date: 7/23/98

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Analysis Report for

BNA FOR NOAA

Project Name: Whitmarsh Landfill **LIMS Project ID:** 1831-98

Sample: 98248008 **Date Received:** 06/12/98 **Method:** SW8270
Field ID: S SED **Date Prepared:** 06/18/98 **Matrix:** Sediment/Soil
Project Officer: Art Johnson **Date Analyzed:** 07/15/98 **Units:** ug/Kg dw

Tentatively Identified Compounds

CAS Number	Analyte Description	Result	Qualifier
1123097	*2-Cyclohexen-1-one, 3,5-dimethyl-*	3750	NJ
768490	*Benzene, (2-methyl-1-propenyl)-*	143	NJ
13616825	*2,4-Dimethylthiophenol*	233	NJ
18800538	*3,4-Dimethylthiophenol*	183	NJ
529204	*Benzaldehyde, 2-methyl-*	336	NJ
103822	*Benzeneacetic acid*	377	NJ
2004695	*3-Penten-1-yne, (E)-*	414	NJ
98920	*Niacinamide*	1750	NJ
638539	*Tridecanoic acid*	1670	NJ
506514	*1-Tetracosanol*	1050	NJ
544638	*Tetradecanoic acid*	12400	NJ
1454848	*1-Nonadecanol*	2770	NJ
1120258	*9-Hexadecenoic acid, methyl ester, (Z)-*	2970	NJ
57103	*Hexadecanoic acid*	33200	NJ
150867	*Phytol*	17400	NJ
23470000	*Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl*	1660	NJ
1599673	*1-Docosene*	2130	NJ
516916	*Cholest-5-ene, 3-bromo-, (3.beta.)-*	257	NJ
297030	*Cyclotetracosane*	3230	NJ
80977	*Cholestanol*	3560	NJ
17472785	*Ergosta-5,22-dien-3-ol, (3.beta.,22E,24S*	4100	NJ
20780410	*Ergosta-5,24-dien-3-ol, (3.beta.)-*	3720	NJ
26047314	*Ergost-7-en-3-ol, (3.beta.)-*	3250	NJ
83476	*.gamma.-Sitosterol*	4580	NJ
*3001950	*C1-Naphthalenes*	159	NJ
*3001951	*C2 -Naphthalenes*	319	NJ
*3001954	*C1-Fluorenes*	115	U
*3001955	*C2-Fluorenes*	115	U
*3001952	*C3 -Naphthalenes*	115	U
*3001956	*C3-Fluorenes*	115	U
*3001953	*C4 -Naphthalenes*	115	U
*3001957	*C1-Dibenzothiophenes*	115	U
*3001960	*C1-Phenanthrenes/Anthracenes*	494	NJ
*3001961	*C2-Phenanthrenes/Anthracenes*	115	U
*3001958	*C2-Dibenzothiophenes*	115	U

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Analysis Report for

BNA FOR NOAA

Project Name: Whitmarsh Landfill **LIMS Project ID:** 1831-98

Sample: 98248008 **Date Received:** 06/12/98 **Method:** SW8270
Field ID: S SED **Date Prepared:** 06/18/98 **Matrix:** Sediment/Soil
Project Officer: Art Johnson **Date Analyzed:** 07/15/98 **Units:** ug/Kg dw

Tentatively Identified Compounds (continued)

CAS Number	Analyte Description	Result	Qualifier
*3001959	*C3-Dibenzothiophenes*	115	U
*3001962	*C3-Phenanthrenes/Anthracenes*	115	U
*3001963	*C4-Phenanthrenes/Anthracenes*	115	U
*3001964	*C1-Fluoranthene/Pyrene*	115	U
*3001965	*C1-Chrysenes*	115	U
*3001966	*C2-Chrysenes*	115	U
*3001967	*C3-Chrysenes*	115	U
*3001968	*C4-Chrysenes*	115	U

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Department of Ecology

Analysis Report for

Volatile Organic Analysis + top 10 TIC's CLP

Project Name: Whitmarsh Landfill **LIMS Project ID:** 2552-98

Sample: 98328001 **Date Collected:** 08/07/98 **Method:** SW8260
Field ID: PADILLA **Matrix:** Sediment/Soil
Project Officer: Art Johnson **Date Analyzed:** 08/12/98 **Units:** ug/Kg dw

Tentatively Identified Compounds

CAS Number	Analyte Description	Result	Qualifier
75183	*Dimethyl sulfide*	14	NJ

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Department of Ecology

Analysis Report for

Volatile Organic Analysis + top 10 TIC's CLP

Project Name: Whitmarsh Landfill **LIMS Project ID:** 2552-98

Sample: 98328002 **Date Collected:** 08/07/98 **Method:** SW8260
Field ID: LAGOON E **Matrix:** Sediment/Soil
Project Officer: Art Johnson **Date Analyzed:** 08/12/98 **Units:** ug/Kg dw

Tentatively Identified Compounds

CAS Number	Analyte Description	Result	Qualifier
75183	*Dimethyl sulfide*	208	NJ
589811	*Heptane, 3-methyl-*	1.1	NJ

Authorized By: [signature] Release Date: 9/22/98 Page: 3

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Department of Ecology

Analysis Report for

Volatile Organic Analysis + top 10 TIC's CLP

Project Name: Whitmarsh Landfill
LIMS Project ID: 2552-98

Sample: 98328003
Date Collected: 08/07/98
Method: SW8260
Field ID: LAGOON MID
Matrix: Sediment/Soil
Project Officer: Art Johnson
Date Analyzed: 08/12/98
Units: ug/Kg dw

Tentatively Identified Compounds

CAS Number	Analyte Description	Result	Qualifier
75183	*Dimethyl sulfide*	306	NJ

Authorized By: [signature] Release Date: 9/22/98

Manchester Environmental Laboratory

Department of Ecology

Analysis Report for

Volatile Organic Analysis + top 10 TIC's CLP

Project Name: Whitmarsh Landfill **LIMS Project ID:** 2552-98

Sample: 98328004 **Date Collected:** 08/07/98 **Method:** SW8260
Field ID: LAGOON W **Matrix:** Sediment/Soil
Project Officer: Art Johnson **Date Analyzed:** 08/12/98 **Units:** ug/Kg dw

Tentatively Identified Compounds

CAS Number	Analyte Description	Result	Qualifier
75183	*Dimethyl sulfide*	174	NJ
5911046	*Nonane, 3-methyl-*	224	NJ
7146603	*Octane, 2,3-dimethyl-*	244	NJ
17301949	*Nonane, 4-methyl-*	560	NJ
17302282	*Nonane, 2,6-dimethyl-*	1170	NJ
17302328	*Nonane, 3,7-dimethyl-*	263	NJ
2114423	*Cyclohexane, 2-propenyl-*	343	NJ
74630301	*2-Decene, 4-methyl-, (Z)-*	261	NJ
1758889	*Benzene, 2-ethyl-1,4-dimethyl-*	415	NJ
535773	*Benzene, 1-methyl-3-(1-methylethyl)-*	707	NJ
933982	*Benzene, 1-ethyl-2,3-dimethyl-*	715	NJ
4176049	*Bicyclo[4.1.0]heptan-3-one, 4,7,7-trimethyl-, [1R-(*	1000	NJ
95932	*Benzene, 1,2,4,5-tetramethyl-*	211	NJ
527537	*Benzene, 1,2,3,5-tetramethyl-*	240	NJ
*3008002	*Unknown 02*	518	NJ
*3008001	*Unknown 01*	422	NJ

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Analysis Report for

BNA FOR NOAA

Project Name: Whitmarsh Landfill **LIMS Project ID:** 2552-98

Sample: 98328000 **Date Collected:** 08/07/98 **Method:** SW8270
Field ID: SAMISH **Date Prepared:** 08/13/98 **Matrix:** Sediment/Soil
Project Officer: Art Johnson **Date Analyzed:** 09/22/98 **Units:** ug/Kg dw

Tentatively Identified Compounds

CAS Number	Analyte Description	Result	Qualifier
112801	*Oleic Acid*	357	NJ
57114	*Octadecanoic acid*	215	NJ
57885	*Cholesterol*	718	NJ

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Analysis Report for

BNA FOR NOAA

Project Name: Whitmarsh Landfill **LIMS Project ID:** 2552-98

Sample: 98328001
Field ID: PADILLA
Project Officer: Art Johnson

Date Collected: 08/07/98
Date Prepared: 08/13/98
Date Analyzed: 09/22/98

Method: SW8270
Matrix: Sediment/Soil
Units: ug/Kg dw

Tentatively Identified Compounds

CAS Number	Analyte Description	Result	Qualifier
544638	*Tetradecanoic acid*	522	NJ
334485	*Decanoic acid*	1000	NJ
2091294	*9-Hexadecenoic acid*	4620	NJ
57103	*Hexadecanoic acid*	5860	NJ
57114	*Octadecanoic acid*	659	NJ
506309	*Eicosanoic acid*	188	NJ
112856	*Docosanoic acid*	610	NJ
77899037	*1-Heneicosyl formate*	1030	NJ
57885	*Cholesterol*	2940	NJ

Authorized By: ______ Release Date: 11/2/98

Manchester Environmental Laboratory

Department of Ecology

Analysis Report for

BNA FOR NOAA

Project Name: Whitmarsh Landfill **LIMS Project ID:** 2552-98

Sample: 98328002 **Date Collected:** 08/07/98 **Method:** SW8270
Field ID: LAGOON E **Date Prepared:** 08/21/98 **Matrix:** Sediment/Soil
Project Officer: Art Johnson **Date Analyzed:** 09/25/98 **Units:** ug/Kg dw

Tentatively Identified Compounds

CAS Number	Analyte Description	Result	Qualifier
544638	*Tetradecanoic acid*	898	NJ
5746587	*Tetradecanoic acid, 12-methyl-, (S)-*	986	NJ
112801	*Oleic Acid*	772	NJ
57114	*Octadecanoic acid*	781	NJ
57885	*Cholesterol*	4240	NJ
80977	*Cholestanol*	846	NJ
34347289	*Cholesta-5,22-dien-3-ol, (3.beta.)-*	1040	NJ
83476	*.gamma.-Sitosterol*	2110	NJ

Authorized By: [signature] Release Date: 11/2/98

Manchester Environmental Laboratory

Department of Ecology

Analysis Report for

BNA FOR NOAA

Project Name: Whitmarsh Landfill **LIMS Project ID:** 2552-98

Sample: 98328003 **Date Collected:** 08/07/98 **Method:** SW8270
Field ID: LAGOON MID **Date Prepared:** 08/13/98 **Matrix:** Sediment/Soil
Project Officer: Art Johnson **Date Analyzed:** 09/22/98 **Units:** ug/Kg dw

Tentatively Identified Compounds

CAS Number	Analyte Description	Result	Qualifier
1534083	*Ethanethioic acid, S-methyl ester*	811	NJ
334485	*Decanoic acid*	1800	NJ
112390	*Hexadecanoic acid, methyl ester*	1070	NJ
10157763	*Benzenesulfonic acid, 4-methyl-, dodecyl ester*	473	NJ
1654860	*Decanoic acid, decyl ester*	2200	NJ
57885	*Cholesterol*	8940	NJ
17472785	*Ergosta-5,22-dien-3-ol, (3.beta.,22E,24S*	2470	NJ
83476	*.gamma.-Sitosterol*	12600	NJ

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Manchester Environmental Laboratory

Department of Ecology

Analysis Report for

BNA FOR NOAA

Project Name: Whitmarsh Landfill

LIMS Project ID: 2552-98

Sample: 98328004
Field ID: LAGOON W
Project Officer: Art Johnson

Date Collected: 08/07/98
Date Prepared: 08/13/98
Date Analyzed: 09/22/98

Method: SW8270
Matrix: Sediment/Soil
Units: ug/Kg dw

Tentatively Identified Compounds

CAS Number	Analyte Description	Result	Qualifier
100538	*Benzenemethanethiol*	104000	NJ
38360815	*3,5-Dimethylthiophenol*	16700	NJ
18800538	*3,4-Dimethylthiophenol*	13400	NJ
118729	*2,6-Dimethylthiophenol*	18400	NJ
13616825	*2,4-Dimethylthiophenol*	12600	NJ
622639	*Benzene, 1-(ethylthio)-4-methyl-*	7580	NJ
2381217	*Pyrene, 1-methyl-*	21500	NJ
139651	*Benzenamine, 4,4'-thiobis-*	29500	NJ
257976	*Benzo(b)phenazine*	74700	NJ
21905668	*Benzoic acid, 2-(4-hydroxyphenoxy)-, methyl ester*	68900	NJ
41555162	*4,7-Benzofurandione, 3-(hydroxymethyl)-6-methoxy-5-*	39800	NJ

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Appendix F

Example TEQ Calculation

Appendix F. Example TEQ Calculation for Padilla Bay Lagoon Sediment Sample #248008

PCDD/PCDF Congener	TEF	Concentration (ng/Kg, dry)	TEQ (ng/Kg, dry)
2,3,7,8-TCDD	1	0.22	0.22
1,2,3,7,8-PCDD	0.5	0.83	0.42
1,2,3,4,7,8-HxCDD	0.1	1.4	0.14
1,2,3,6,7,8-HxCDD	0.1	4.9	0.49
1,2,3,7,8,9-HxCDD	0.1	4.5	0.45
1,2,3,4,6,7,8-HpCDD	0.01	68	0.68
OCDD	0.001	490	0.49
2,3,7,8-TCDF	0.1	1.9	0.19
1,2,3,7,8-PCDF	0.05	0.52	0.03
2,3,4,7,8-PCDF	0.5	0.78	0.39
1,2,3,4,7,8-HxCDF	0.1	1.5	0.15
1,2,3,6,7,8-HxCDF	0.1	0.73	0.07
2,3,4,6,7,8-HxCDF	0.1	1.2	0.12
1,2,3,7,8,9-HxCDF	0.1	0.2 U	
1,2,3,4,6,7,8-HpCDF	0.01	12	0.12
1,2,3,4,7,8,9-HpCDF	0.01	0.89	0.01
OCDF	0.001	30	0.03
		Total TEQ =	4.0

U = Not detected at or above reported value (i.e., less than)

Appendix G

Data Appendix

Appendix G is printed as a separate report, Publication No. 99-307