



Screening Survey for Petroleum Contamination at Cornet Bay Marina (Island County)

September 2005

Publication No. 05-03-033

printed on recycled paper



This report is available on the Department of Ecology home page on the World Wide Web at www.ecy.wa.gov/biblio/0503033.html

For a printed copy of this report, contact:

Department of Ecology Publications Distributions Office

Address: PO Box 47600, Olympia WA 98504-7600

E-mail: ecypub@ecy.wa.gov

Phone: (360) 407-7472

Refer to Publication Number 05-03-033.

Data for this project are available at Ecology's Environmental Information Management (EIM) website www.ecy.wa.gov/eim/index.htm. Search User Study ID, KKIN0001.

Ecology's Project Tracker code for this project is 06-074.

Any use of product or firm names in this publication is for descriptive purposes only and does not imply endorsement by the author or the Department of Ecology.

If you need this publication in an alternate format, call Joan LeTourneau at (360) 407-6764. For persons with a speech or hearing impairment, call 711 for relay service or 800-833-6388 for TTY.

Screening Survey for Petroleum Contamination at Cornet Bay Marina (Island County)

*by
Kristin Kinney*

Environmental Assessment Program
Olympia, Washington 98504-7710

September 2005

Waterbody No. WA-PS-0010

Publication No. 05-03-033

printed on recycled paper



This page is purposely left blank for duplex printing

Table of Contents

	<u>Page</u>
List of Figures and Tables.....	ii
Abstract.....	iii
Acknowledgements.....	iv
Introduction.....	1
Project Description.....	4
Methods.....	5
Study Design.....	5
Field Procedures.....	7
Analytical Methods.....	10
Data Quality.....	11
Laboratory Case Narrative Summary.....	11
Results.....	12
Groundwater.....	12
Surface Water.....	14
Sediments.....	16
Discussion.....	22
Conclusions and Recommendations.....	29
References.....	31
Appendices	
A. Historical Data	
B. Data Quality Assessment	
C. Case Narratives	

List of Figures and Tables

	<u>Page</u>
Figures	
Figure 1. Location of Cornet Bay and Study Site.....	2
Figure 2. Groundwater, Surface Water, and Sediment Sampling Stations at Cornet Bay Marina, 2005.....	3
Figure 3. BTEX, Gasoline, and Diesel Concentrations in Groundwater, Surface Water, and Sediment.....	23
Figure 4. BTEX, Gasoline, and Diesel Concentrations in Monitoring Well 2, 1996, 2003 and 2005	24
Figure 5. BTEX, Gasoline, and Diesel Concentrations in Monitoring Well 3, 1996, 2003, and 2005.....	24
Figure 6. LPAHs in Sediments	27
Figure 7. HPAHs in Sediments.....	28
Tables	
Table 1. Sampling Station Locations at Cornet Bay Marina, 2005	6
Table 2. Sample Containers, Preservation, and Holding Times for Water and Sediment Samples	8
Table 3. Laboratory Methods for Water and Sediment Samples.....	10
Table 4. Summary of Quality Control Samples Analyzed	11
Table 5. Groundwater Results and Field Data.....	12
Table 6. Hydrocarbon Identification Analysis Results	13
Table 7. Surface Water Results.....	15
Table 8. Sediment Results, Dry Weight.....	17
Table 9. Sediment Results, Organic Compounds, TOC Normalized	19
Table 10. Groundwater Results for TPH-Gx, TPH-Dx, and BTEX, 2003 and 2005	22

Abstract

In 1989, a fuel release from an underground storage tank at Cornet Bay Marina on Whidbey Island contaminated the groundwater. In 2005, groundwater, surface water, and sediment samples were collected onsite to determine if petroleum contaminants were currently migrating into the adjacent intertidal areas. Samples were analyzed for petroleum products including TPH-Gx, TPH-Dx, BTEX, and PAHs.

Groundwater continues to be contaminated in two of the monitoring wells, with levels of gasoline, diesel, and benzene exceeding Model Toxics Control Act Method A cleanup levels for groundwater.

No significant petroleum contamination was found in the two streams bracketing the site to the north and south.

Sediments along the bulkhead showed no evidence of BTEX, gasoline, or diesel, with the exception of one site at the southern end which had low levels of BTEX and diesel. PAHs were detected at all sediment sampling locations. PAH levels were low in the surrounding intertidal area, but exceeded the sediment management standards criteria at all sampling sites along the bulkhead. PAHs exceeded the cleanup screening levels at four of the six stations adjacent to the bulkhead, and the sediment quality standards were exceeded for multiple PAHs at all six stations.

The extent to which the spilled petroleum has contributed to the PAH levels observed in Cornet Bay Marina sediments is uncertain. Hydrocarbon ID analysis suggests that the PAHs in the sediments are due to the creosote treated bulkhead.

Acknowledgements

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

- Staff from the Ecology/EPA Manchester Environmental Laboratory including Bob Carrell, Dickey Huntamer, Dean Momohara, and Dolores Montgomery.
- Dale Norton for guidance in planning this study, assistance with sampling, and reviewing the draft report.
- Pam Marti for assistance with groundwater sampling and reviewing the draft report.
- Art Johnson for reviewing the draft report.
- Joan LeTourneau for formatting and editing the final report.

Introduction

Background

Cornet Bay is located at the north end of Whidbey Island in Island County, which lies west of the mainland city of Mt. Vernon, Washington (Figure 1). Cornet Bay Marina, at 200 West Cornet Bay Road North, has existed since the 1960s. A wooden bulkhead about 250 feet long separates the upland area and store from the marina (Figure 2). The site is bound on the east by Cornet Bay Road and a mixture of residential and light commercial land uses. Depth to groundwater is approximately five feet, and groundwater flow is diagonally across the site toward the northwest. Upland soil is a mixture of clay, silt, sand, gravel, and some peat.

Four underground storage tanks were installed next to each other on the site in 1964. Combined, they had a total capacity for 18,000 gallons of gasoline and 3,000 gallons of diesel. There was a major release in 1989, allegedly from ruptured underground fuel lines, in which fuel inundated the groundwater and seeped into the bay along the bulkhead. Sheen was observed emanating from the bulkhead for up to a year after the release, and for several years from the northern-most area on the bulkhead.

After the release the tanks were pumped dry, and in March 1990 they were all removed. In November 1990 a large concrete vault was constructed at the same location where the four tanks were removed. A single 12,000 gallon tank was installed in the vault. This compartmentalized tank contains 9,000 gallons of gas and 3,000 gallons diesel. Records indicate the contaminated soil was put back into the excavation, and it is suspected that some of it was hauled offsite to an unknown location (Nye, personal communication).

In 1995 Ecology investigated the site with 13 soil borings and installed three monitoring wells. There was no further work on the site until June 2003. During June 2003 the monitoring wells were sampled for the second time. Ten geoprobe borings that sampled soil and groundwater were also completed.

The 2003 data indicate that, since 1996, contaminant levels had attenuated in the well in the center of the site (MW-3), but had increased in the well at the north end of the site (MW-2). This well is downgradient of the location of the current and historical underground storage tanks. The complete historical data set is included in Appendix A.

Contaminant levels in soils from 2003 were generally the same as those found in 1996, indicating attenuation was not occurring over time. Gasoline and diesel range total petroleum hydrocarbons (TPH-Gx and TPH-Dx), as well as benzene, toluene, ethylbenzene, and xylene (BTEX) concentrations, were above the Model Toxics Control Act (MTCA) Method A cleanup levels for unrestricted land uses (WAC 173-340-900). The highest levels were present in borings DP1, DP5, DP9, and DP10.

Grab groundwater samples were taken from nine of the borings. Contaminant levels exceeded Method A standards in all nine borings for benzene, eight borings for TPH-Gx, and six borings for TPH-Dx. Contaminant levels were particularly high in borings DP7, DP8, DP9, and DP2.

Prior to this study, intertidal sediments had never been evaluated for petroleum contamination at this location.

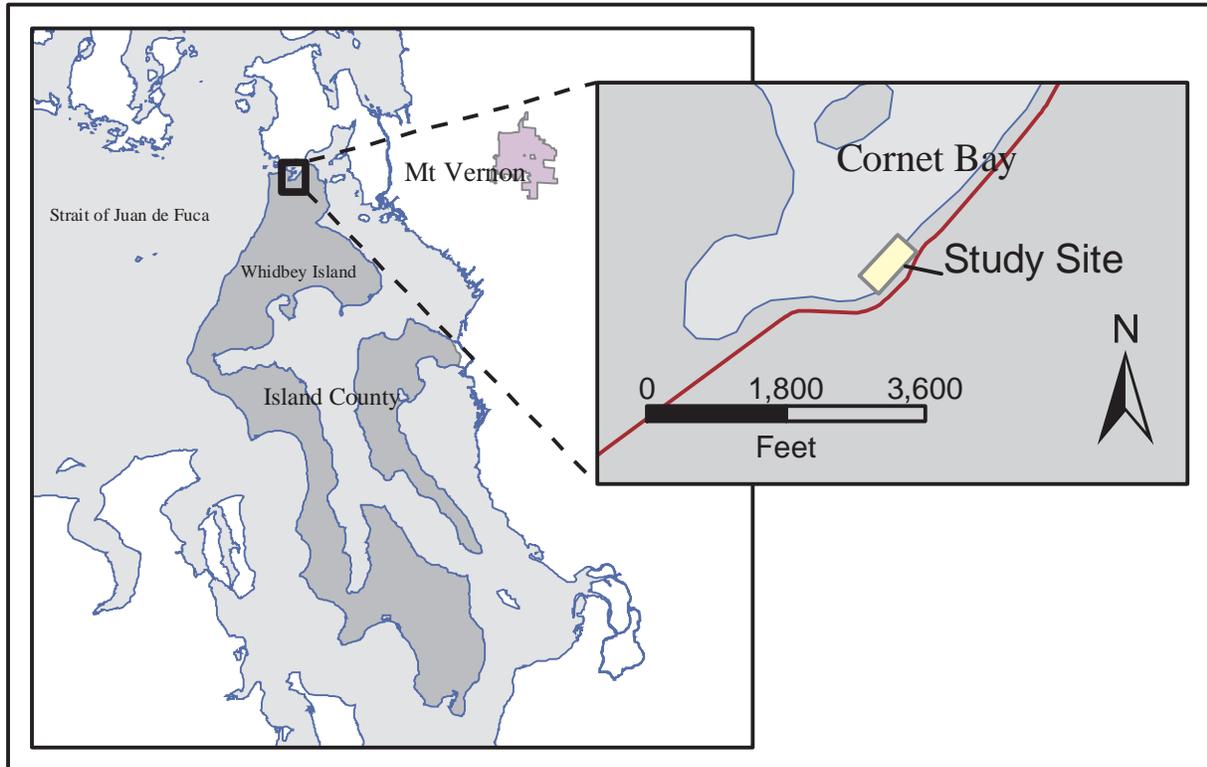


Figure 1. Location of Cornet Bay and Study Site.

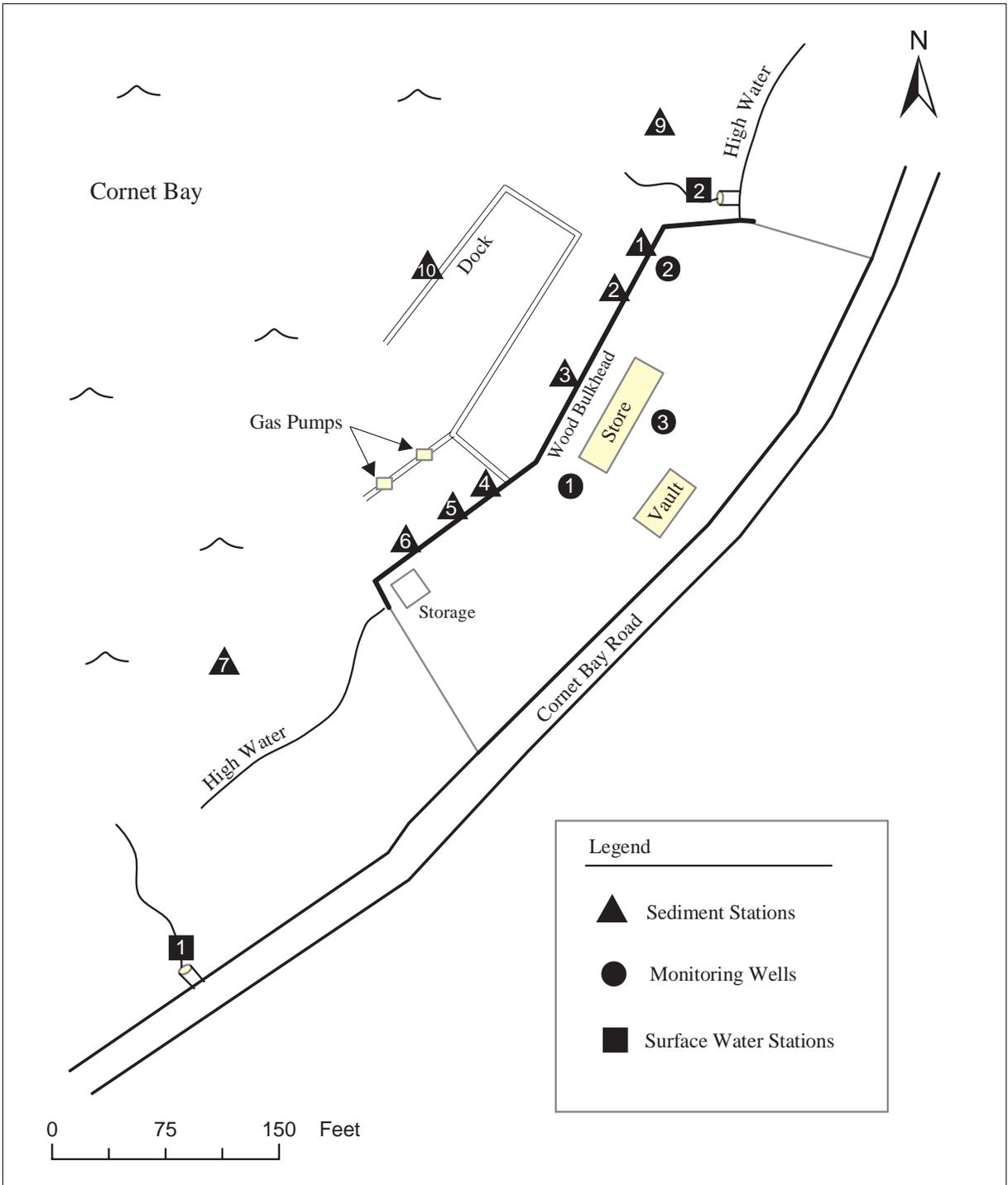


Figure 2. Groundwater, Surface Water, and Sediment Sampling Stations at Cornet Bay Marina, 2005.

Project Description

The primary goal of this project was to evaluate the nearshore intertidal area to determine if upland contamination presents a significant ongoing source of petroleum products. This was accomplished by collecting and analyzing intertidal sediments, surface water, and groundwater.

The data collected will be used by the Washington State Department of Ecology (Ecology) Toxics Cleanup Program to determine the need to include remediation and/or institutional controls of sediments in the total site cleanup.

The objectives of the study were to:

- Determine if ongoing migration of petroleum contaminants into intertidal areas of Cornet Bay is occurring.
- Evaluate the significance of intertidal contaminant levels present by comparison to applicable environmental and human health standards.

The study was conducted by Ecology's Environmental Assessment Program following a Quality Assurance Project Plan (Kinney, 2005). Field work was conducted April 27-28, 2005.

Methods

Study Design

Groundwater was collected from the three existing upland monitoring wells to determine current conditions and evaluate the possibility that groundwater is an ongoing transport mechanism for contaminants. Any potential sediment contamination caused by the spills could be matched to the pattern seen in the wells.

Surface water samples were collected from two small streams, on the north and south sides of the site, that empty into the bay through culverts at the high water mark. The streams originate offsite and flow over the surface on the periphery of the site and not over the main area affected by the release. High contaminant levels in these waters could indicate additional sources upgradient of the site.

Sediment sampling sites were concentrated on the bulkhead area, where sheen was observed after the spill (Table 1, Figure 2). Six sediment samples were collected immediately adjacent to the bulkhead, with two additional samples bracketing the site to the north and south. One additional sample was collected off of a dock to the west of the bulkhead.

The collection of shellfish was part of the original sampling plan (Kinney, 2005), but clams were only sparsely present at the site. With only one or two clams found over a large area of the tideflats, and along the length of the bulkhead, it would be difficult to evaluate any potential contamination gradient on the site or to make a comparison between discrete sampling locations. In addition, this area does not appear to be used by the public for shell fishing. For these reasons, tissue samples were not collected.

Table 1. Sampling Station Locations at Cornet Bay Marina, 2005.

Station Name	Sample Number	Date	Time	Latitude Decimal Measure	Longitude Decimal Measure	Notes
Groundwater						
CBMGW-1	174093	4/28/2005	1030	48.397778	122.625556	
	174094	4/28/2005	1950	---	---	Pump Blank
CBMGW-2	174095	4/28/2005	1430	48.398056	122.625278	
CBMGW-3	174096	4/28/2005	1230	48.397704	122.62661	
CBMGW-3 (Rep)	174097	4/28/2005	1230	48.397704	122.62661	Field Replicate Sample
Surface Water						
CBMSW-1	174088	4/27/2005	1048	48.396944	122.626667	
CBMSW-2	174089	4/27/2005	1130	48.398333	122.625278	
	174090	4/27/2005	1130	---	---	Transfer Blank
Sediment						
CBMSED-1	174080	4/27/2005	1205	48.397973	122.626668	
CBMSED-2	174081	4/27/2005	1225	48.397909	122.626713	
CBMSED-3	174082	4/27/2005	1235	48.397764	122.626808	
CBMSED-3 (Dup)	174087	4/27/2005	1240	48.397764	122.626808	Duplicate Split Sample
CBMSED-4	174083	4/27/2005	1305	48.397569	122.627022	
CBMSED-5	174084	4/27/2005	1325	48.397529	122.627056	
CBMSED-6	174085	4/27/2005	1340	48.39748	122.627126	
CBMSED-7	174086	4/27/2005	1440	48.3975	122.626388	
CBMSED-9	174091	4/27/2005	1450	48.398203	122.626719	
CBMSED-10	174092	4/27/2005	1600	48.397845	122.627129	

Datum = NAD83 HARN

Field Procedures

Groundwater

Prior to sampling the three monitoring wells, static water levels (recorded to 0.01 feet) were measured using a commercial electric probe. The probe was rinsed with deionized water and wiped clean between measurements. The monitoring wells were purged and sampled using a Grundfos Redi-Flo2 stainless steel submersible pump with dedicated tubing. The pump intake was placed at the middle of the screened interval in each monitoring well and purged at a pump rate of 0.5 to 1 liter/minute.

Wells were purged through a continuous flow cell until pH, conductivity, and temperature readings stabilized. Purge water from the wells was stored onsite in a 55-gallon drum until it could be transported and disposed of in accordance with Washington State regulations (Chapter 173-340-400 WAC).

Monitoring well samples were collected directly from the pump discharge line after purging, placed into appropriate containers, sealed in ziplock bags, and placed on ice for transport to Ecology headquarters. Samples were taken to Manchester Laboratory the following day. Chain-of-custody was maintained throughout the process. All sample locations for the study were recorded using a hand-held Magellan 320 global positioning system (GPS). BTEX and TPH-Gx samples were field preserved with two drops of 1:1 HCl. The pump was decontaminated between each well by circulating laboratory grade detergent/water through the pump, followed by a tap water rinse, with each cycle lasting five minutes.

A sampling blank was run through the submersible pump for five minutes, transferred to a sample container, and analyzed for BTEX, TPH-Gx, and TPH-Dx. A complete set, except hydrocarbon ID (HCID), of field replicate samples for groundwater were collected from monitoring well MW-3 by filling two sets of sample containers sequentially.

Surface Water

Single grab samples for BTEX, TPH-Gx and lead in surface water were collected from the culvert opening. Multiple grabs with a hand-held glass jar were composited into 1-gallon glass jars for polynuclear aromatic hydrocarbons (PAHs), TPH-Dx, and HCID samples. Temperature and pH were measured using an Orion Model 250A temperature-compensating pH meter, and conductivity was measured using a Beckman conductivity meter. Flow was estimated using a bucket and stopwatch to estimate gallons per second.

BTEX and TPH-Gx samples were field preserved with two drops of 1:1 HCl. Immediately after collection, sample containers from each station were sealed in ziplock plastic bags and placed in an ice filled cooler. Samples were transported to Ecology headquarters, stored at 4° C, and then taken to Manchester Laboratory the next day. Chain-of-custody was maintained throughout the process.

A transfer blank was prepared at CBMSW-2 by pouring organic-free water prepared by Manchester Laboratory into sample containers.

The original project plan included sampling groundwater surface seeps, but none with sufficient flow to sample were located on the site.

Sediments

Sediment collection methods followed PSEP (1996) protocols and requirements of Ecology's Sediment Management Standards (Chapter 173-204 WAC; Ecology, 2003). Sediments were collected at nine stations, at low tide on April 27, 2005, between 1205 and 1450 hours.

At each sampling location except CBMSED-10, sediments to a depth of 10cm were transferred to a pre-cleaned stainless steel mixing bowl using a stainless steel spoon, and homogenized. The top 10cm was sampled because it represents the biologically active zone (Ecology, 2003). Subsamples of the homogenized sediment were placed in sample containers for grain size, percent solids, total organic carbon (TOC), HCID, PAHs, and lead (Table 2). In order to minimize volatilization, samples for TPH-Gx, TPH-Dx, and BTEX were not taken from the homogenized sediment, but rather were immediately transferred from each site into sample containers.

Table 2. Sample Containers, Preservation, and Holding Times for Water and Sediment Samples.

Parameter	Sample Container	Preservation	Holding Time
Water			
BTEX & TPH-Gx	(3) 40 mL VOA vials w/ septum, per station	1:1 HCl pH<2, Cool to 4° C	14 days if preserved with HCl
TPH-Dx	1 gal glass jar	Cool to 4° C	14 days
PAH	1 gal glass jar	Cool to 4° C	7 days
Lead	500 mL HDPE bottle	HNO ₃ to pH < 2 (by lab within 24 hours of arrival)	6 months
Hydrocarbon ID	1 gal glass jar	Cool to 4° C	7 days until extraction
Sediment			
BTEX & TPH-Gx	(2) 2 oz septa jars, per station	Cool to 4° C	14 days ¹
TPH-Dx	4 oz glass jar	Cool to 4° C	14 days
PAH's	8 oz glass jar	Cool to 4° C	14 days
Lead	4 oz glass jar	Cool to 4° C	6 months
Hydrocarbon ID	8 oz glass jar	Cool to 4° C	14 days until extraction
% Solids	2 oz glass jar	Cool to 4° C	7 days
Grain Size	8 oz plastic jar	Cool to 4° C	6 months
TOC	2 oz glass jar	Cool to 4° C	14 days

¹ – Samples must be delivered to lab within 48 hours

The CBMSED-10 sample was taken off the dock west of the bulkhead using a 0.01 m² Petite Ponar grab sampler, and was a composite of three grabs. The top 10cm was taken for analysis, homogenized, and subsampled as described above.

All sediment samples were placed in ziplock bags and coolers with ice. Samples were taken to Ecology headquarters and stored at 4° C until being transported to Manchester Laboratory the next day. Chain-of-custody was maintained throughout the process. Stainless steel spoons and mixing bowls were precleaned with Liquinox® detergent, followed by sequential rinses with tap water, 10% nitric acid, deionized water, acetone, and hexane. All equipment was air-dried and then individually wrapped completely in foil.

A complete set of sediment duplicate samples was taken at CBMSED-3 by splitting a single homogenized sample into two separate samples (duplicate split).

Analytical Methods

Groundwater was analyzed for TPH-Gx, TPH-Dx, BTEX, and HCID, and field measurements were taken for pH, temperature, and conductivity. Surface water was analyzed for TPH-Gx, TPH-Dx, BTEX, PAHs, HCID, and lead, with the addition of pH, temperature, and conductivity field measurements. Sediments were analyzed for TPH-Gx, TPH-Dx, BTEX, PAHs, HCID, lead, percent solids, grain size, and TOC.

Sample containers were cleaned to EPA (1990) Quality Assurance/Quality Control specifications and certified for trace organic analyses. The methods used to analyze samples collected for this study are listed in Table 3. All of the analyses were conducted by Manchester Laboratory except grain size which was analyzed by Analytical Resources, Incorporated in Tukwila, Washington.

Table 3. Laboratory Methods for Water and Sediment Samples.

Parameter	Preparation Method	Analytical Method	Reference
Water			
BTEX		SW8021B	EPA 1996
TPH-Gx	NWTPH-GxP	NWTPH-Gx	Ecology 1997
TPH-Dx	NWTPH-DxP	NWTPH-Dx	Ecology 1997
Hydrocarbon ID		HYDRO-ID	Ecology 1997
PAHs		EPA 8270C	EPA 1996
Lead	EPA 200.8	EPA 200.8	EPA 1994
Hardness as CaCO ₃		EPA 200.7/SM 2340B	APHA, 1998
Sediment			
BTEX		SW8260B	EPA 1996
TPH-Gx	NWTPH-GxP	NWTPH-Gx	Ecology 1997
TPH-Dx	NWTPH-DxP	NWTPH-Dx	Ecology 1997
PAHs	SW3630B	SW8270C	EPA 1996
Lead	EPA 3050B	EPA 200.8	EPA 1994
Hydrocarbon ID		HYDRO-ID	Ecology 1997
% Solids		SM 2540G	APHA, 1998
Grain Size		Plumb 1981	EPA/CE81-1
TOC		PSEP - TOC	PSEP 1996

Data Quality

Laboratory Case Narrative Summary

No significant problems were encountered in the analyses, and in general data met measurement quality objectives established in the Quality Assurance Project Plan (Kinney, 2005). A summary of problems encountered is contained in Appendix B.

Manchester Laboratory prepared written case narratives assessing the quality of the data collected for this project. These reviews include a description of analytical methods and an assessment of holding times, initial and continuing calibration and degradation checks, method blanks, surrogate recoveries, matrix spike recoveries, laboratory control samples, and laboratory duplicate samples (Appendix C).

The complete Manchester Laboratory data reports are available from the author on request. Project data are also available electronically through the Ecology Environmental Information Management System (EIM) at www.ecy.wa.gov/eim/index.htm, under User Study ID KKIN0001.

A summary of quality control samples analyzed for this project is in Table 4.

Table 4. Summary of Quality Control Samples Analyzed.

Quality Control Sample	Groundwater	Surface Water	Sediment
Transfer Blank		X	
Pump Blank	X		
Field Replicate	X		
Duplicate Split			X
Matrix Spike/Matrix Spike Duplicate		X	X
Laboratory Duplicate			X

Results

Groundwater

TPH-Gx, TPH-Dx, and BTEX were analyzed in samples from three existing monitoring wells on the site (Table 5). Depth to water was similar to measurements taken in 2003. No contamination was found in monitoring well MW-1, whereas diesel was detected in 2003 (Appendix A-3). Concentrations of diesel, gasoline, benzene, and ethylbenzene had also decreased in MW-2 since 2003. In the current study, the detection limit for diesel was high in MW-2 (3,000 ug/L), making it difficult to determine if diesel was present in the groundwater at this location. Benzene, ethylbenzene, gasoline, and diesel increased in MW-3 since 2003, while xylenes appear to have reduced. The limit of detection was not low enough for toluene in this sample to allow for comparison to concentrations found in 2003.

Table 5. Groundwater Results and Field Data (ug/L).

	MTCA ¹ (A) groundwater (ug/L)	MW-1		MW-2		MW-3			
		CBMGW-1 05174093		CBMGW-2 05174095		CBMGW-3 05174096	CBMGW-3 (Rep) 05174097		
Total Petroleum Hydrocarbons (ug/L)									
Gasoline	800	140	U	2600		1400		1300	
#2 Diesel	500	48	U	3000	UJ	31000		7600	
Volatile Monoaromatic Hydrocarbons (ug/L)									
Benzene	5	1.0	U	7300	J	260		270	
Toluene	1000	1.0	U	10	U	10	U	10	U
Ethylbenzene	700	1.0	U	84		91		97	
m & p-Xylene	(1000) ²	2.0	U	20	U	20	U	20	U
o-Xylene	(1000) ²	1.0	U	10	U	10	U	10	U
Conventional Parameters									
Temperature (°C)	---	13.6		15.5		14.5		---	
pH	---	7.74		6.75		6.91		---	
Conductivity (umhos/cm)	---	881		181		447		---	
Static groundwater level ³ (ft)	---	5.66		7 ⁴		4.05		---	
Petroleum odor	---	no		yes		yes		---	

¹ Model Toxics Control Act (MTCA) Method A Cleanup Level for Ground Water, WAC 173-340-900.

² Criteria for total xylenes

³ Depth to water below a fixed spot at the top of the well casing rim.

⁴ Value is approximate. Interference prohibited a clear reading.

Bold Exceeds MTCA Method A

U Analyte was not detected at or above the reported result.

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

UJ Analyte was not detected at or above the reported estimated result.

A field replicate sample taken in MW-3 (CBMGW-3 Rep) showed good precision for BTEX and TPH-Gx, but poor precision for TPH-Dx (Appendix Table B-1). The relative percent difference (RPD) for TPH-Dx (121%) exceeded the acceptable level established in the Quality Assurance Project Plan. The discrepancy between the two samples could be due to free product in the monitoring well. The surrogate recoveries for the sample and the replicate could not be determined due to the large dilutions that were necessary for these samples. The average of the two diesel replicates was similar to the level measured in 2003 (Appendix Table A-3).

Gasoline, benzene, and ethylbenzene were all detected in MW-2, north of the vault. Measured gasoline and benzene levels exceeded MTCA Method A cleanup levels. Monitoring well MW-3, located between the store and the vault, also exceeded MTCA standards for gasoline and benzene, as well as diesel. Ethylbenzene was detected in MW-3 at levels below MTCA Method A cleanup criteria (Table 5).

These samples give a snapshot assessment of the petroleum concentrations in the groundwater. More data would need to be collected, during different times of the year, to have an accurate assessment of current groundwater contamination and to determine if concentrations have increased overall.

Results from the hydrocarbon identification analysis showed the monitoring well north of the store (CBMGW-2) contained weathered gasoline. The well east of the store (CBMGW-3) contained either weathered #2 diesel or #2 fuel oil (red diesel), which are typically identical chromatographically (Table 6).

Table 6. Hydrocarbon Identification Analysis Results.

Station Name	Sample Number	Comments
Groundwater		
CBMGW-1	05174093	Does not contain any recognizable petroleum hydrocarbons
CBMGW-2	05174095	Contains weathered gasoline
CBMGW-3	05174096	Contains weathered #2 diesel or #2 fuel oil (red diesel)
Surface Water		
CBMSW-1	05174088	Contains a small amount of unknown compounds
CBMSW-2	05174089	Does not contain any recognizable hydrocarbon pattern
Sediment		
CBMSED-1	05174080	Contains weathered coal tar creosote
CBMSED-2	05174081	Contains weathered coal tar creosote
CBMSED-3	05174082	Contains weathered coal tar creosote
CBMSED-3 (Dup)	05174087	Contains an unknown mixture of compounds
CBMSED-4	05174083	Contains weathered coal tar creosote
CBMSED-5	05174084	Contains weathered coal tar creosote
CBMSED-6	05174085	Contains a lube oil and a weathered coal tar creosote
CBMSED-7	05174086	Does not contain any recognizable hydrocarbon pattern
CBMSED-9	05174091	Contains small amount of weathered creosote
CBMSED-10	05174092	Contains small amount of unknown compounds

Surface Water

No PAHs or petroleum hydrocarbons were found in the surface water samples. Low concentrations (0.085 and 0.096 ug/L) of lead were detected in both streams, and xylene was found in one sample also at a low level (1.1 ug/L) (Table 7).

Hydrocarbon identification analysis was conducted on these samples, and neither contained any recognizable hydrocarbon pattern (Table 6).

Table 7. Surface Water Results (ug/L).

	Station Name:	CBMSW-1	CBMSW-2
	Sample Number:	05174088	05174089
Metals (ug/L, dissolved)			
WAC WQ standards acute		95.12	95.83
WAC WQ standards chronic		3.71	3.73
Lead* (dissolved)		0.085	0.096
Total Petroleum Hydrocarbons (ug/L)			
Gasoline		0.14 U	0.14 U
#2 Diesel		0.049 U	0.048 U
Non-ionizable Organic Compounds (ug/L)			
Polynuclear Aromatic Hydrocarbons			
Naphthalene		0.06 U	0.07 U
Acenaphthylene		0.06 U	0.07 U
Acenaphthene		0.06 U	0.07 U
Fluorene		0.06 U	0.07 U
Phenanthrene		0.06 U	0.07 U
Anthracene		0.06 U	0.07 U
2-Methylnaphthalene		0.06 U	0.07 U
Total LPAH		0.06 U	0.07 U
Fluoranthene		0.06 U	0.07 U
Pyrene		0.06 U	0.07 U
Benzo(a)anthracene		0.06 U	0.07 U
Chrysene		0.06 U	0.07 U
Benzo(b+k)fluoranthene		0.06 UJ	0.07 UJ
Benzo(a)pyrene		0.06 U	0.07 U
Indeno(1,2,3-cd)pyrene		0.06 U	0.07 U
Dibenzo(a,h)anthracene		0.06 U	0.07 U
Benzo(ghi)perylene		0.06 U	0.07 U
Total HPAH		0.06 U	0.07 U
Other Non-ionizable Organic Compounds			
1-Methylnaphthalene		0.06 U	0.07 U
2-Chloronaphthalene		0.06 U	0.07 U
Carbazole		0.06 U	0.07 U
Dibenzofuran		0.06 U	0.07 U
Retene		0.06 U	0.07 U
Volatile Monoaromatic Hydrocarbons (ug/L)			
Benzene		1.0 U	1.0 U
Toluene		1.0 U	1.0 U
Ethylbenzene		1.0 U	1.0 U
m & p-Xylene		2.0 U	2.0 U
o-Xylene		1.0 U	1.1
Other			
Hardness as CaCO ₃ (mg/L)		143	144

Bold Detected analyte

* Hardness dependent

U Analyte was not detected at or above the reported result.

UJ Analyte was not detected at or above the reported estimated result.

Sediments

Sand comprised the highest percentage of the grain sizes for most sediment samples, with the exception of two samples that had a greater percentage of silt (Table 8). Percent fines for these two samples from the south end of the site (60%) and off the dock to the west of the site (92%) were much higher than the other samples. Percent fines for the remaining samples varied between 11% and 19%. Total organic carbon (TOC) values varied between 0.36% and 2.07% and were within the range that is typical for Puget Sound marine sediments (Michelson et al., 1992).

No gasoline was found in any of the sediment samples. Two diesel samples had reporting limits which exceeded limits established in the Quality Assurance Project Plan (Kinney, 2005). Diesel and BTEX were detected at one station (CBMSED-6) (Table 8).

LPAH and HPAH (low and high molecular weight PAHs) were detected at all sediment sampling locations, and exceeded criteria at multiple sites.

Lead was detected in all sediment samples, but at levels well below criteria. The dry weight lead results from intertidal sediments are similar to lead levels found in bore holes adjacent to the monitoring wells in 1995 and at a sampling site at the southern end of the site (B-10) Appendix Table A-1). When normalized to percent fines, the lowest lead levels were found in the outlying intertidal areas to the north and south, and off the dock to the west of the site.

All sediment data collected in Washington State are evaluated using the Sediment Management Standards (SMS), Chapter 173-204 WAC. The SMS establishes two numerical standards for sediment quality: the sediment quality standards (SQS) and the cleanup screening levels (CSL). SQSs represent a level above which minor adverse effects may occur, and CSLs represent a level above which significant adverse effects may occur in benthic organisms.

Under the SMS rule, the numerical sediment standards for non-ionizable organic chemicals in marine sediment are organic carbon normalized. Non-ionizable contaminants in water or sediments preferentially partition into the organic material in sediments because of their similar chemical nature (Michelsen et al., 1992). DiToro et al. (1991) and others have shown that the toxicity of non-ionizable, organic chemicals in sediments appears to be correlated to the concentration of those chemicals in the organic carbon fraction of sediments, and not to the dry weight concentration. In this study, values for non-ionizable organic compounds, including PAHs, were normalized using the measured TOC content of each sample (Table 9).

SQS exceedances were found in all sediment sample locations except three: CBMSED-7 and CBMSED-9, located in the intertidal zone south and north of the site, respectively, and CBMSED-10, adjacent to a dock west of the marina. CSL exceedances of multiple LPAHs and HPAHs were found at three stations, all adjacent to the bulkhead: CBMSED-2, CBMSED-3, and CBMSED-5. One analyte (chrysene) exceeded CSL criteria at station CBMSED-6, also adjacent to the bulkhead.

Table 8. Sediment Results, Dry Weight.

Station Name: Sample Number:	CBMSED-1 05174080	CBMSED-2 05174081	CBMSED-3 05174082*	CBMSED-3 (Dup) 05174087*	CBMSED-4 05174083
Metals (mg/Kg)					
Lead	4.83	4.1	3.61	4.07	4.73
Total Petroleum Hydrocarbons (mg/Kg)					
Gasoline	9.3 U	9.0 U	8.5 U	8.3 U	9.3 U
#2 Diesel	17 U	18 U	19 U	91 UJ	20 U
Non-ionizable Organic Compounds (PAHs) (ug/Kg)					
Naphthalene	80	94	139	164	39
Acenaphthylene	28	45	90	172	38
Acenaphthene	288	226	702	832	32
Fluorene	218	314	760	1380	59
Phenanthrene	1610 J	2890 J	5900 J	10200 J	387 J
Anthracene	256	341	1260	1600	259
2-Methylnaphthalene	15	66	44	133	19
Total LPAH	2480 J	3910 J	8850 J	14300 J	814 J
Fluoranthene	4340	4300	12300	21100	2770
Pyrene	3490	3500	10400	19100	2090
Benzo(a)anthracene	404	577	1880	3440	372
Chrysene	1750	2040	4030	7800	2280
Benzo(b)fluoranthene	369 J	493 J	1050 J	2010 J	368 J
Benzo(k)fluoranthene	526 J	570 J	691 J	2870 J	494 J
Total benzofluoranthenes	895 J	1063 J	1741 J	4880 J	862 J
Benzo(a)pyrene	235	318	657	1340	287
Indeno(1,2,3-cd)pyrene	119	141	285	495	134
Dibenzo(a,h)anthracene	46	62	134	247	61
Benzo(ghi)perylene	107	131	255	437	125
Total HPAH	11400 J	12100 J	31700 J	58800 J	8980 J
Other Non-ionizable Organic Compounds (ug/Kg)					
1-Methylnaphthalene	111	62	118	175	15
2-Chloronaphthalene	5.4 U	5 U	5.2 U	5.2 U	4.8 U
Carbazole	32	137	218	414	27
Dibenzofuran	150	239	385	616	42
Retene	46	78	5.2 U	5.2 U	10
Volatile Monoaromatic Hydrocarbons (ug/Kg)					
Benzene	1.9 U	1.6 U	1.8 U	1.5 U	1.5 U
Toluene	1.9 U	1.6 U	1.8 U	1.5 U	1.5 U
Ethylbenzene	1.9 U	1.6 U	1.8 U	1.5 U	1.5 U
m & p-Xylene	3.8 U	3.2 U	3.5 U	3.1 U	3.1 U
o-Xylene	1.9 U	1.6 U	1.8 U	1.5 U	1.5 U
Other (%)					
Solids	74	77	76	76	75
Total Organic Carbon	0.61	0.41	0.75	0.72	0.68
Grain Size (%)					
Gravel	9	11	27	31	33
Sand	78	78	59	52	53
Silt	8	7	9	12	10
Clay	5	4	5	5	4
Fines	13	11	14	16	14

¹ Average of triplicate analysis

* Samples 05174082 and 05174087 are a duplicate split.

U Analyte was not detected at or above the reported result.

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

UJ Analyte was not detected at or above the reported estimated result.

Table 8 (continued).

Station Name: Sample Number:	CBMSED-5 05174084	CBMSED-6 05174085	CBMSED-7 05174086	CBMSED-9 05174091	CBMSED-10 05174092
Metals (mg/Kg)					
Lead	5.17	6.92	6.17	3.2	9.42
Total Petroleum Hydrocarbons (mg/Kg)					
Gasoline	9.7 U	9.2 U	11 U	8.5 U	15 U
#2 Diesel	16 U	57	23 U	18 U	34 U
Non-ionizable Organic Compounds (PAHs) (ug/Kg)					
Naphthalene	140	116	4.8 J	4.9 U	5 J
Acenaphthylene	101	44	1.1 U	4.9 U	9.4 U
Acenaphthene	276	107	1.1 J	4.9 U	9.4 U
Fluorene	548	122	4 J	4.9 U	4.2 J
Phenanthrene	7170 J	718 J	28 J	72 J	35 J
Anthracene	608	324	9.1	4.9 U	18
2-Methylnaphthalene	41	65	8.7	4.9 U	9.5
Total LPAH	8840 J	1430 J	47 J	72 J	62 J
Fluoranthene	10000	4720	73	173	72
Pyrene	8770	4880	86	128	109
Benzo(a)anthracene	1460	550	24	16	32
Chrysene	3960	2980	52	62	78
Benzo(b)fluoranthene	1060 J	439 J	24 J	24 J	52 J
Benzo(k)fluoranthene	1430 J	634 J	28 J	27 J	36 J
Total benzo(a)fluoranthenes	2490 J	1073 J	52 J	51 J	88 J
Benzo(a)pyrene	742	365	19	10	35
Indeno(1,2,3-cd)pyrene	348	167	14	7.3	23
Dibenzo(a,h)anthracene	170	72	7	2.3 J	9.8
Benzo(ghi)perylene	322	148	19	9	31
Total HPAH	28300 J	14960 J	346 J	459 J	478 J
Other Non-ionizable Organic Compounds (ug/Kg)					
1-Methylnaphthalene	76	58	6 J	4.9 U	6.9 J
2-Chloronaphthalene	5.5 U	5.5 U	6.1 U	4.9 U	9.4 U
Carbazole	164	74	6.1 U	4.9 U	9.4 U
Dibenzofuran	284	100	3 J	4.9 U	3.4 J
Retene	5.5 U	25	27	13	20
Volatile Monoaromatic Hydrocarbons (ug/Kg)					
Benzene	1.6 U	1.6	2.0 U	1.6 U	3.3 U
Toluene	1.6 U	1.6	2.0 U	1.6 U	3.3 U
Ethylbenzene	1.6 U	1.6	2.0 U	1.6 U	3.3 U
m & p-Xylene	3.3 U	3.2	4.0 U	3.2 U	6.5 U
o-Xylene	1.6 U	1.6	2.0 U	1.6 U	3.3 U
Other (%)					
Solids	72	73	62	76	42
Total Organic Carbon	0.83	0.50	1.37	0.36	2.07
Grain Size (%)					
Gravel	39	20	0 ¹	2	0
Sand	43	61	40 ¹	81	8
Silt	11	12	46 ¹	12	66
Clay	7	6	14 ¹	5	26
Fines	17	19	60 ¹	17	92

¹ Average of triplicate analysis

* Samples 05174082 and 05174087 are a duplicate split.

U Analyte was not detected at or above the reported result.

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

UJ Analyte was not detected at or above the reported estimated result.

Table 9. Sediment Results, Organic Compounds, TOC normalized.

			CBMSED-1	CBMSED-2	CBMSED-3	CBMSED-3 (Dup)	CBMSED-4
	SQS	CSL	05174080	05174081	05174082*	05174087*	05174083
Non-ionizable Organic Compounds (PAHs) (mg/Kg)							
Naphthalene	99	170	13	23	18	23	5.7
Acenaphthylene	66	66	4.6	11	12	24	5.6
Acenaphthene	16	57	47	55	94	120	4.7
Fluorene	23	79	36	77	100	190	8.7
Phenanthrene	100	480	260 J	700 J	790 J	1400 J	57 J
Anthracene	220	1200	42	83	170	220	38
2-Methylnaphthalene	38	64	2.5	16	5.9	18	2.8
Total LPAH	370	780	403 J	949 J	1184 J	1977 J	120 J
Fluoranthene	160	1200	710	1000	1600	2900	410
Pyrene	1000	1400	570	850	1400	2700	310
Benzo(a)anthracene	110	270	66	140	250	480	55
Chrysene	110	460	290	500	540	1100	330
Benzo(b+k)fluoranthene ¹	230	450	150 J	260 J	230 J	680 J	130 J
Benzo(a)pyrene	99	210	38	78	88	190	42
Indeno(1,2,3-cd)pyrene	34	88	19	34	38	69	20
Dibenzo(a,h)anthracene	12	33	7.5	15	18	34	9.0
Benzo(ghi)perylene	31	78	18	32	34	61	18
Total HPAH	960	5300	1869 J	2909 J	4198 J	8214 J	1324 J
Other Non-ionizable Organic Compounds (mg/Kg)							
1-Methylnaphthalene	---	---	18	15	16	24	2.2
2-Chloronaphthalene	---	---	0.9 U	1 U	0.69 U	0.72 U	0.71 U
Carbazole	---	---	5.2	33	29	57	4.0
Dibenzofuran	15	58	25	58	51	86	6.2
Retene	---	---	7.5	19	0.69 U	0.72 U	1.5
Other (%)							
Total Organic Carbon	---	---	0.61	0.41	0.75	0.72	0.68

Exceeds Cleanup Screening Level (CSL) Chapter 173-204 WAC

Bold Exceeds Sediment Quality Standard (SQS) Chapter 173-204 WAC

¹ Criteria for total benzofluoranthenes (j+b+k)

* Samples 05174082 and 05174087 are a duplicate split.

U Analyte was not detected at or above the reported result.

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

Table 9 (continued)

	SQS	CSL	CBMSED-5 05174084	CBMSED-6 05174085	CBMSED-7 05174086	CBMSED-9 05174091	CBMSED-10 05174092
Non-ionizable Organic Compounds (PAHs) (mg/Kg)							
Naphthalene	99	170	17	23	0.35 J	1.4 U	0.2 J
Acenaphthylene	66	66	12	8.8	0.080 U	1.4 U	0.45 U
Acenaphthene	16	57	33	21	0.080 J	1.4 U	0.45 U
Fluorene	23	79	66	24	0.3 J	1.4 U	0.20 J
Phenanthrene	100	480	860 J	140 J	2.0 J	20 J	1.7 J
Anthracene	220	1200	73	65	0.66	1.4 U	0.87
2-Methylnaphthalene	38	64	4.9	13	0.63	1.4 U	0.46
Total LPAH	370	780	1061 J	282 J	3 J	20 J	3 J
Fluoranthene	160	1200	1200	940	5.3	48	3.5
Pyrene	1000	1400	1100	980	6.3	36	5.27
Benzo(a)anthracene	110	270	180	110	1.7	4.4	1.5
Chrysene	110	460	480	600	3.8	17	3.8
Benzo(b+k)fluoranthene ¹	230	450	300 J	210 J	3.8 J	14 J	4.2 J
Benzo(a)pyrene	99	210	89	73	1.4	2.8	1.7
Indeno(1,2,3-cd)pyrene	34	88	42	33	1.0	2.0	1.1
Dibenzo(a,h)anthracene	12	33	20	14	0.5	0.64 J	0.47
Benzo(ghi)perylene	31	78	39	30	1.4	2	1.50
Total HPAH	960	5300	3450 J	2990 J	25 J	127 J	23 J
Other Non-ionizable Organic Compounds (mg/Kg)							
1-Methylnaphthalene	---	---	9.2	12	0.4 J	1.4 U	0.33 J
2-Chloronaphthalene	---	---	0.66 U	1.1 U	0.44 U	1.4 U	0.45 U
Carbazole	---	---	20	15	0.44 U	1.4 U	0.45 U
Dibenzofuran	15	58	34	20	0.2 J	1.4 U	0.16 J
Retene	---	---	0.66 U	5	2.0	3.6	0.97
Other (%)							
Total Organic Carbon	---	---	0.83	0.50	1.37	0.36	2.07

Exceeds Cleanup Screening Level (CSL) Chapter 173-204 WAC

Bold Exceeds Sediment Quality Standard (SQS) Chapter 173-204 WAC

¹ Criteria for total benzofluoranthenes (j+b+k)

* Samples 05174082 and 05174087 are a duplicate split.

U Analyte was not detected at or above the reported result.

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

A few sites had detections of other non-ionizable organic compounds. Of these, dibenzofuran is the only compound that has established criteria. Dibenzofuran exceeded the CSL at two sites, and at four sites exceeded the SQS. At CBMSED-3 a duplicate split analysis was performed on the sample with one result showing an SQS exceedance and the duplicate showing a CSL exceedance (Table 9).

Qualitative hydrocarbon analysis showed that all sediment samples adjacent to the bulkhead (stations CBMSED 1-6) and sediment taken from the tideflats north of the site (CBMSED-9) contained weathered coal tar creosote as evidenced by the presence of the PAHs fluoranthene and pyrene (Table 6). Station CBMSED-6 at the southern end of the bulkhead also contained lube oil. The remaining sediment samples did not contain any recognizable petroleum compounds or products, but small amounts of unknown compounds were present to varying degrees.

Samples 05174082 and 05174087 were a duplicate split sample. The results for sample 05174087 were about 80% higher than for sample 05174082 (Appendix Table B-8). One of the samples could have contained a globule of oil, in which case, mixing of the sample would not shear and spread the oil evenly, resulting in a consistently higher level of contaminants in one sample.

Discussion

Contamination persists in the groundwater at Cornet Bay Marina. Gas, diesel, benzene, and ethylbenzene were found in the two monitoring wells (MW-3 and MW-2) that are downgradient of the historic and existing fuel vault (Figure 3). Concentrations in MW-3 have decreased since 1996 but are similar to the 2003 data. Contamination levels have decreased in MW-2 since 2003 (Table 10 and Figures 4 and 5). However, more data would need to be collected, during different times of the year, to have an accurate assessment of the current groundwater contamination and to determine if concentrations have increased or decreased overall.

Diesel, the only compound found in MW-1 in 2003, was not detected in 2005. MW-1 is located upgradient of the fuel vault.

Table 10. Groundwater Results for TPH-Gx, TPH-Dx, and BTEX, 2003 and 2005.

	MTCA (A) ground- water (ug/L)	MW-1		MW-2		MW-3				
			CBM-GW-1 05174093		CBM-GW-2 05174095		CBM-GW-3 05174096	CBM-GW-3 (Rep) 05174097		
		2003	2005	2003	2005	2003	2005			
Total Petroleum Hydrocarbons (ug/L)										
Gasoline	800	50 U	140 U	21300	2600	1170	1400	1300		
#2 Diesel	500	294	48 U	127000	3000 UJ	17200	31000	7600		
Volatile Monoaromatic Hydrocarbons (ug/L)										
Benzene	5	0.5 U	1.0 U	9000	7300 J	185	260	270		
Toluene	1000	0.5 U	1.0 U	50 U	10 U	4.63	10 U	10 U		
Ethylbenzene	700	0.5 U	1.0 U	354	84	86.7	91	97		
m & p-Xylene	---	---	2.0 U	---	20 U	---	20 U	20 U		
o-Xylene	---	---	1.0 U	---	10 U	---	10 U	10 U		
Total Xylenes	1000	1.0 U	---	100 U	---	29.4	---	---		

Bold - detected values

Exceeds Model Toxics Control Act (MTCA) Method A Cleanup Levels for Groundwater

2003 data from Pinnacle GeoSciences

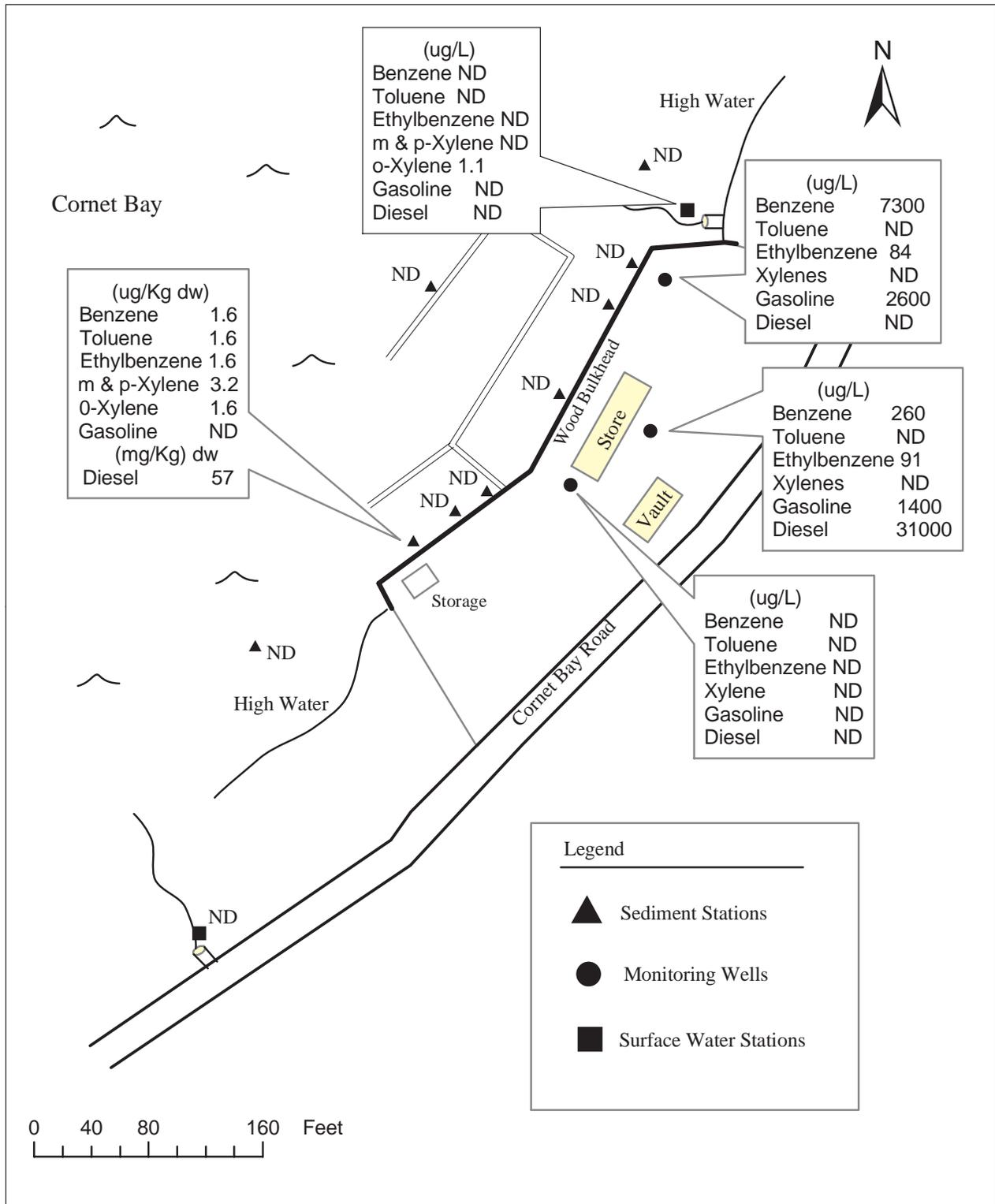


Figure 3. BTEX, Gasoline, and Diesel Concentrations in Groundwater, Surface Water, and Sediment (ND=not detected).

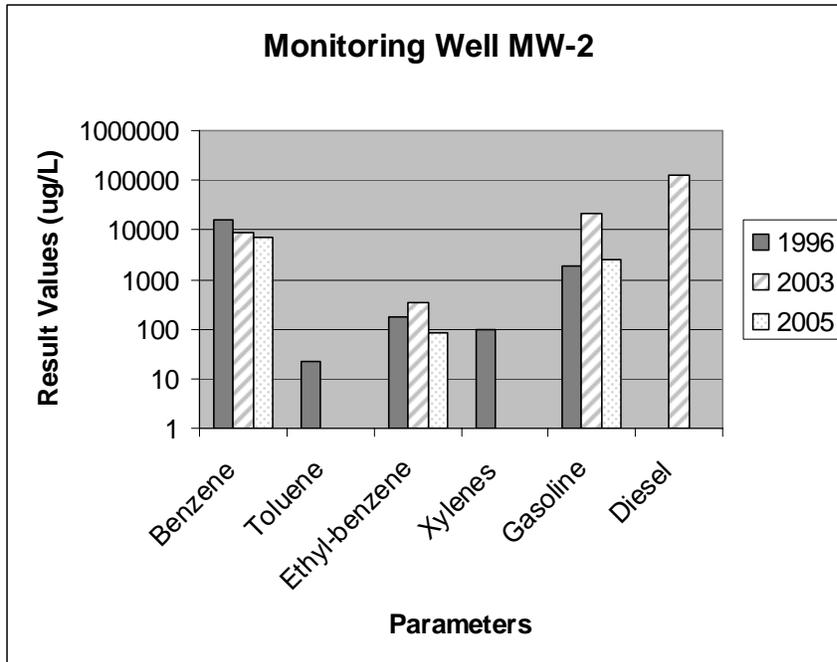


Figure 4. BTEX, Gasoline, and Diesel Concentrations in Monitoring Well 2, 1996, 2003, and 2005 (logarithmic scale).

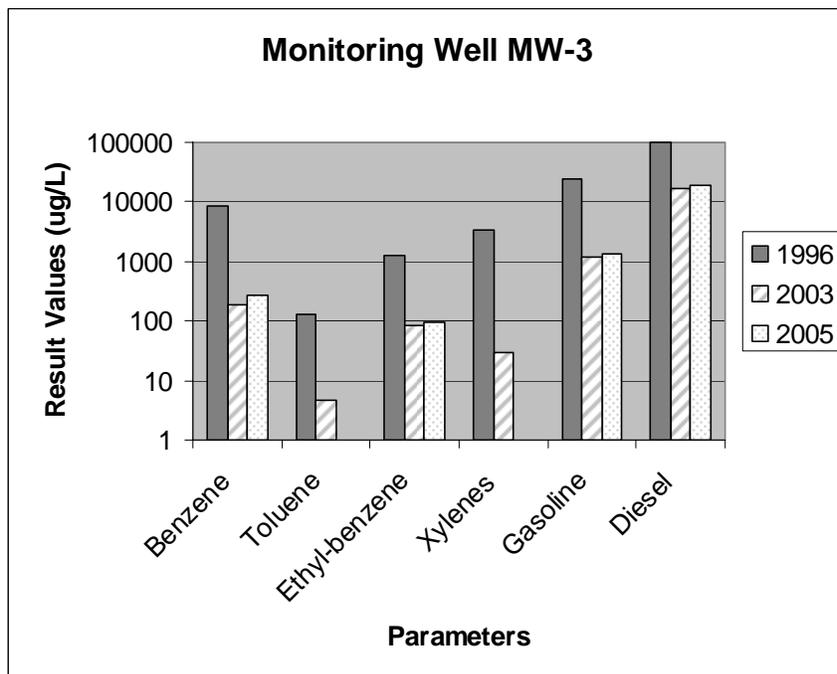


Figure 5. BTEX, Gasoline, and Diesel Concentrations in Monitoring Well 3, 1996, 2003, and 2005 (logarithmic scale).

Method A cleanup levels for groundwater were exceeded for gasoline and benzene in both MW-2 and MW-3 and for diesel in MW-3. Both of these wells are downgradient of the fuel vault. Although results varied between the MW-3 sample and the sample field replicate (MW-3 Rep), both samples exceeded method A for three compounds.

A visible sheen could be seen on the water coming from the bulkhead as the tidal waters dropped. After the tidal waters receded, there were no visible seeps along the bulkhead so it could not be determined if the source of the sheen was groundwater. Contaminants found in the monitoring wells are likely being transported to the surface waters of Cornet Bay, but it is unknown where groundwater from the site enters the bay.

Two streams bracket the site. One has an outlet on the north end of the site, and one on the south end. No petroleum contaminants were found in these surface waters, with the exception of 1.1 ug/L of o-xylene on the north side (Figure 3).

Efforts were taken in the field to limit volatilization of any potential BTEX, gasoline, or diesel present in the sediments. Even so, these compounds were not found in any of the intertidal sediments, with the exception of one sample at the southern end of the bulkhead, at station CBMSED-6 (Figure 3). Diesel was found at this site at a level of 57 mg/Kg dw, and BTEX compounds from 1.6-3.2 ug/Kg dw (0.32 – 0.64 TOC normalized). HCID analysis found lube oil and creosote in the sample. There are no established regulatory levels for these contaminants in sediments.

Sampling station CBMSED-6 was adjacent to the docks containing fuel pumps for the marina, which is a potential source for the diesel contamination. There is a storage shed located on the southwest corner of the site that contains a large drum used as a recycled oil receptacle, but it is uncertain if this could be contributing to the contaminant levels found at CBMSED-6. A soil boring taken in this general location in 1995 found 11-13 mg/Kg dw gasoline, 58-64 mg/Kg dw diesel, and 5-6 mg/Kg dw lead (Appendix Table A-1).

Both LPAHs and HPAHs, as well as other non-ionizable organic compounds, were found at levels exceeding criteria at all sediment sampling locations adjacent to the bulkhead (Table 9). Total LPAH exceeded CSL at three stations, and total HPAH exceeded CSL at one station (Figures 6 and 7).

Elevated concentrations of HPAH are generally attributed to combustion of fossil fuels, while high concentrations of LPAH are generally considered to be indicative of petroleum. Both HPAHs and LPAHs were found at elevated levels at this site. The marina would increase the possibility of finding PAHs along the bulkhead because of the concentration of outboard motor use and the fueling dock's location.

The HCID analysis supports the conclusion that the PAH contamination in the sediments adjacent to the bulkhead is caused by the creosoted bulkhead itself. Coal tar creosote, the most widely used industrial wood preservative in the United States, is a complex mixture typically composed of approximately 85% PAHs (ATSDR, 2005). Blends of creosote with coal tar (50:50) are generally used when treating wood for marine use (Merrill and Wade, 1985).

As with other chemical mixtures, the fate and transport of creosote can be complex. Some components of creosote, such as phenols, are water soluble and migrate easily from contaminated soils or treated wood. PAHs generally have low aqueous solubilities and mobility and tend to sorb to sediments. Lighter PAHs near the soil surface are generally volatilized, oxidized, or biodegraded, and the remaining weathered creosote will show limited ability to move offsite. While many components are degraded, the higher molecular weight PAHs that remain are bioaccumulative and carcinogenic (Beyond Pesticides, 2005).

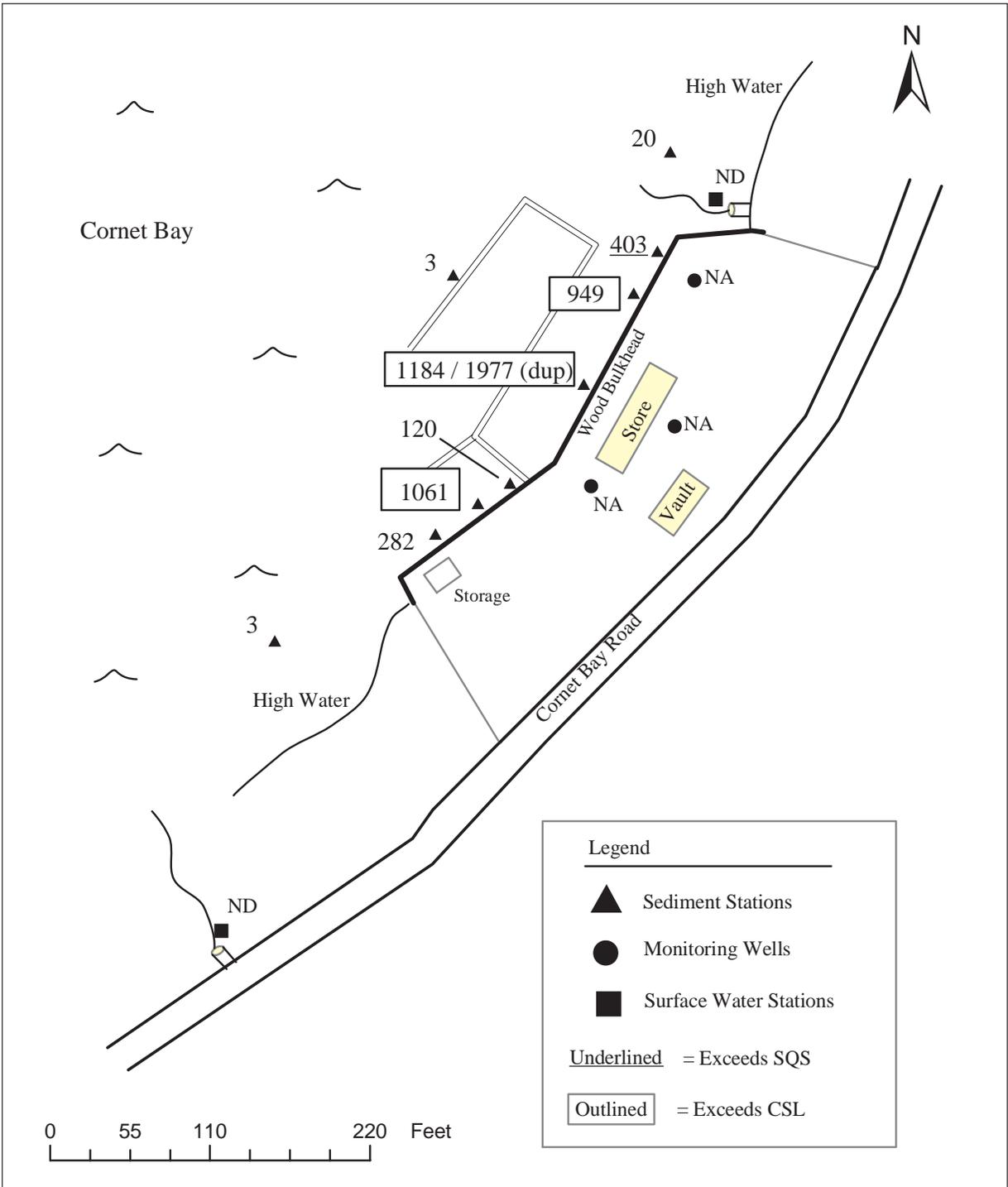


Figure 6. LPAHs in Sediments (mg/Kg TOC normalized) (ND=not detected, NA=not analyzed).

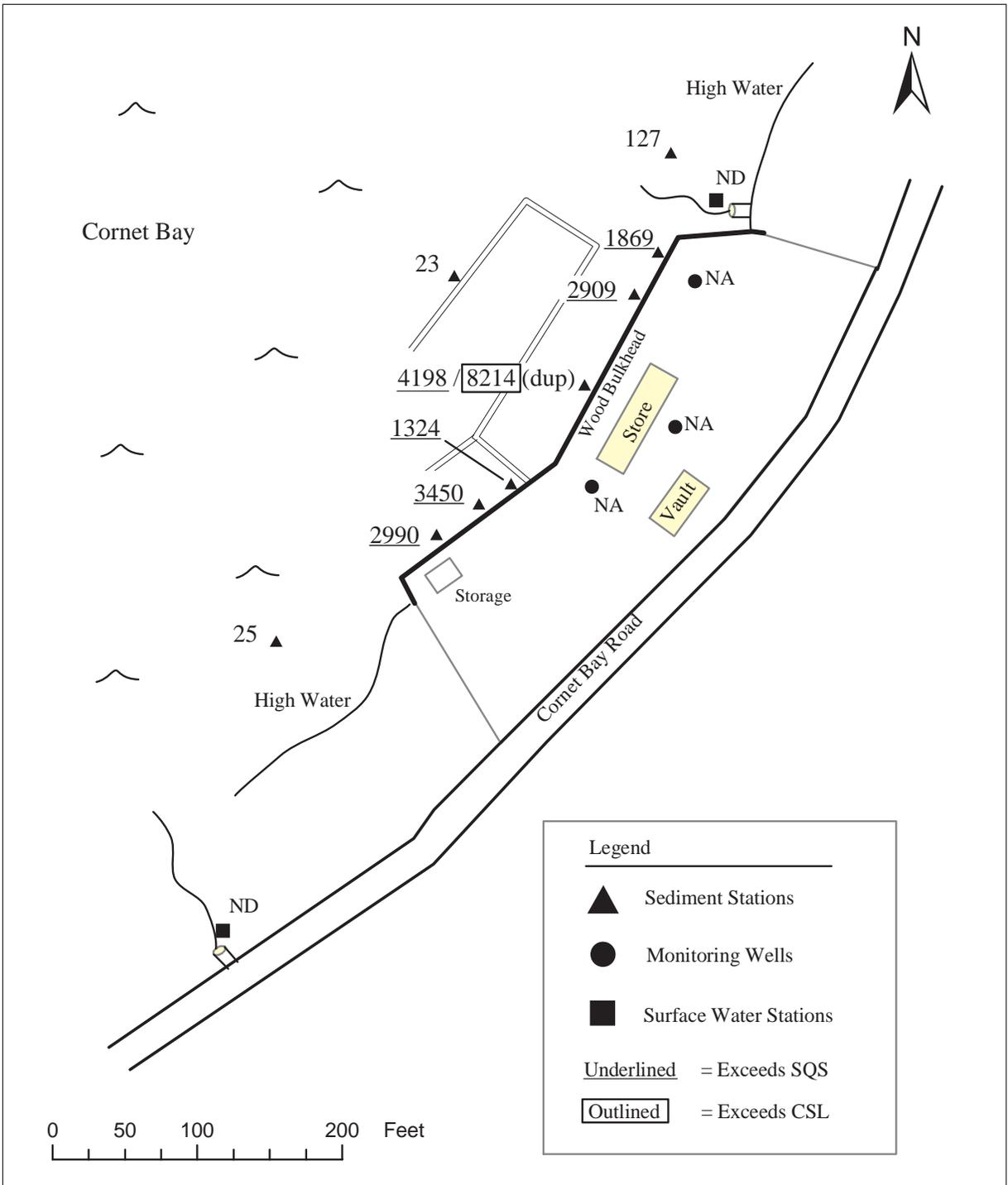


Figure 7. HPAHs in Sediments (mg/Kg TOC normalized) (ND=not detected, NA=not analyzed).

Conclusions and Recommendations

Conclusions

Groundwater continues to be contaminated in two of the monitoring wells, MW-2 and MW-3, at Cornet Bay Marina. Significant contamination exists in these wells, but it cannot be concluded that ongoing contamination to intertidal sediments is occurring without determining where the groundwater is entering Cornet Bay. The contaminated groundwater could be impacting the water column, but based on sediment chemistry results, there is no evidence that gas and diesel are currently contaminating marina sediments. Visual observations suggest that groundwater is delivering petroleum contamination from the upland site to the marine waters of Cornet Bay; a visible sheen coming from the bulkhead can be observed during outgoing tides. However, analytical results suggest that sediment contamination adjacent to the bulkhead is a result of creosote leaching from the bulkhead.

The two streams near the site had no significant petroleum contamination.

Investigation of the sediments along the bulkhead, and on the tideflats to the north and south, showed no evidence of BTEX, gasoline, or diesel, with the exception of one site at the southern end of the bulkhead. However, PAHs were detected at all sediment sampling locations. PAHs exceed the cleanup screening levels (CSL) at four of the six sediment stations adjacent to the bulkhead, and the sediment quality standards (SQS) are exceeded for multiple PAHs at all six stations. The tideflats north and south of the site did not exceed criteria. The source of the diesel and BTEX contamination at the southern end of the bulkhead is unknown.

The extent to which the spilled petroleum has contributed to the PAH levels observed in Cornet Bay Marina sediments is uncertain. Hydrocarbon ID analysis suggests that the PAHs in the sediments are due to creosote.

Both groundwater and sediments continue to exceed cleanup standards 15 years after the 1989 fuel release. PAHs exceed both SQS and CSL along the bulkhead. Intertidal sediments do not appear to be accumulating BTEX, TPH-Gx, or TPH-Dx contamination, but it is likely that the groundwater is continuing to transport the contamination to the surface waters of Cornet Bay.

Summary of Findings:

- All SQS and CSL exceedances in sediments were confined to the area immediately adjacent to the bulkhead.
- All sediment samples adjacent to the bulkhead had more than one SQS exceedance.
- Four the six samples adjacent to the bulkhead had CSL exceedances.
- Surface water does not appear to be inputting contamination from above the site, or function as a vector for transport of contamination away from the site.
- No contamination was found in monitoring well MW-1.
- Gas, diesel, and BTEX levels have decreased in MW-2.
- Gas, diesel, and BTEX levels in MW-3 are similar to levels found in 2003.

Recommendations

Based on the results of this investigation, the following recommendations are provided:

- Additional sampling of groundwater or intertidal sediments to characterize contaminant levels is not recommended at this time. Sampling conducted to date appears to be adequate to establish the presence or absence of contaminants.
- Sediment bioassay toxicity testing is not recommended due to the high cost of these tests and the limited area that is impacted.
- The most visible transport of contaminants away from the site appears to be marine waters that contact the bulkhead during high tide. Sampling of marine waters adjacent to the bulkhead would help determine if water quality impacts are occurring from this bulkhead seepage.

References

- APHA, AWWA, and WEF, 1998. Standard Methods for the Examination of Water and Wastewater, 20th Edition. American Public Health Association, American Water Works Association, and Water Environment Federation. United Book Press, Inc., Baltimore, MD.
- ATSDR, 2005. Agency for Toxic Substances and Disease Registry. U.S. Department of Health and Human Services. www.atsdr.cdc.gov/ (revised 9-23-05). Accessed August 3, 2005.
- Beyond Pesticides, 2005. Beyond Pesticides: National Coalition Against the Misuse of Pesticides. www.beyondpesticides.org Accessed July 11, 2005.
- DiToro, D.M., C.S. Zarba, D.J. Hansen, W.J. Berry, R.C. Swartz, C.E. Cowan, S.P. Pavlou, H.E. Allen, N.A. Thomas, and P.R. Paquin, 1991. Technical Basis for Establishing Sediment Quality Criteria for Nonionic Organic Chemicals Using Equilibrium Partitioning. Environmental Toxicology and Chemistry 10: 1541-1583.
- Ecology, 1997. Analytical Methods for Petroleum Hydrocarbons. Washington State Department of Ecology, Olympia, WA. Publication No. 97-602. www.ecy.wa.gov/biblio/97602.html
- Ecology, 2003. Sediment Sampling and Analysis Plan Appendix – Guidance on the Development of Sediment Sampling and Analysis Plans Meeting the Requirements of the Sediment Management Standards (Chapter 173-204 WAC). Publication No. 03-09-043. www.ecy.wa.gov/biblio/0309043.html. Revised April 2003.
- EPA, 1990. Specifications and Guidance for Obtaining Contaminant-Free Sample Containers. U.S. Environmental Protection Agency. OSWER Directive #93240.0-05.
- EPA, 1994. Methods for the Determination of Metals in Environmental Samples. U.S. EPA National Exposure Research Laboratory (NERL)
- EPA, 1996. SW-846 On-line. U.S. Environmental Protection Agency. www.epa.gov/epaoswer/hazwaste/test/main.htm
- Kinney, K., 2005. Quality Assurance Project Plan: Cornet Bay Intertidal Contaminant Screening Survey. Washington State Department of Ecology, Olympia, WA. Publication No. 05-03-109. www.ecy.wa.gov/biblio/0503109.html
- MEL, 2001. Quality Assurance Manual. Manchester Environmental Laboratory, Washington State Department of Ecology, Manchester, WA.
- MEL, 2003. Manchester Environmental Laboratory Lab User's Manual, Seventh Edition. Manchester Environmental Laboratory, Washington State Department of Ecology, Manchester, WA.

Merrill, E.G. and T.L. Wade, 1985. Carbonized Coal Products as a Source of Aromatic Hydrocarbons to Sediments from a Highly Industrialized Estuary. *Environ. Sci. Technol.* 19: 597-603.

Michelsen, T.C. and K. Bragdon-Cook, 1992. Technical Information Memorandum: Organic Carbon Normalization of Sediment Data. Washington State Department of Ecology, Olympia, WA.

Nye, R., 2005. Personal communication. Washington State Department of Ecology, Northwest Regional Office, Bellevue, WA. April 1, 2005.

Plumb, R.H., Jr., 1981. Procedure for handling and chemical analysis of sediment and water samples. Technical Report EPA/CE-81-1. U.S. Environmental Protection Agency and U.S. Army Corps of Engineers, Waterways Experimental Station, Vicksburg, MS.

PSEP, 1995. Puget Sound Estuary Program (PSEP): Recommended Guidelines for Conducting Laboratory Bioassays on Puget Sound Sediments. U.S. Environmental Protection Agency, Region 10, Office of Puget Sound, Seattle, WA.

PSEP, 1996. Puget Sound Estuary Program (PSEP): Recommended Protocols for Measuring Selected Environmental Variables in Puget Sound, Recommended Guidelines for Measuring Organic Compounds in Puget Sound Water, Sediment and Tissue Samples. April 30, 1996

WAS, 1993. Field Sampling and Measurement Protocols for the Watershed Assessments Section. Washington State Department of Ecology, Olympia, WA. Publication No. 93-e04. www.ecy.wa.gov/biblio/93e04.html.

Appendices

This page is purposely left blank for duplex printing

Appendix A. Historical Data

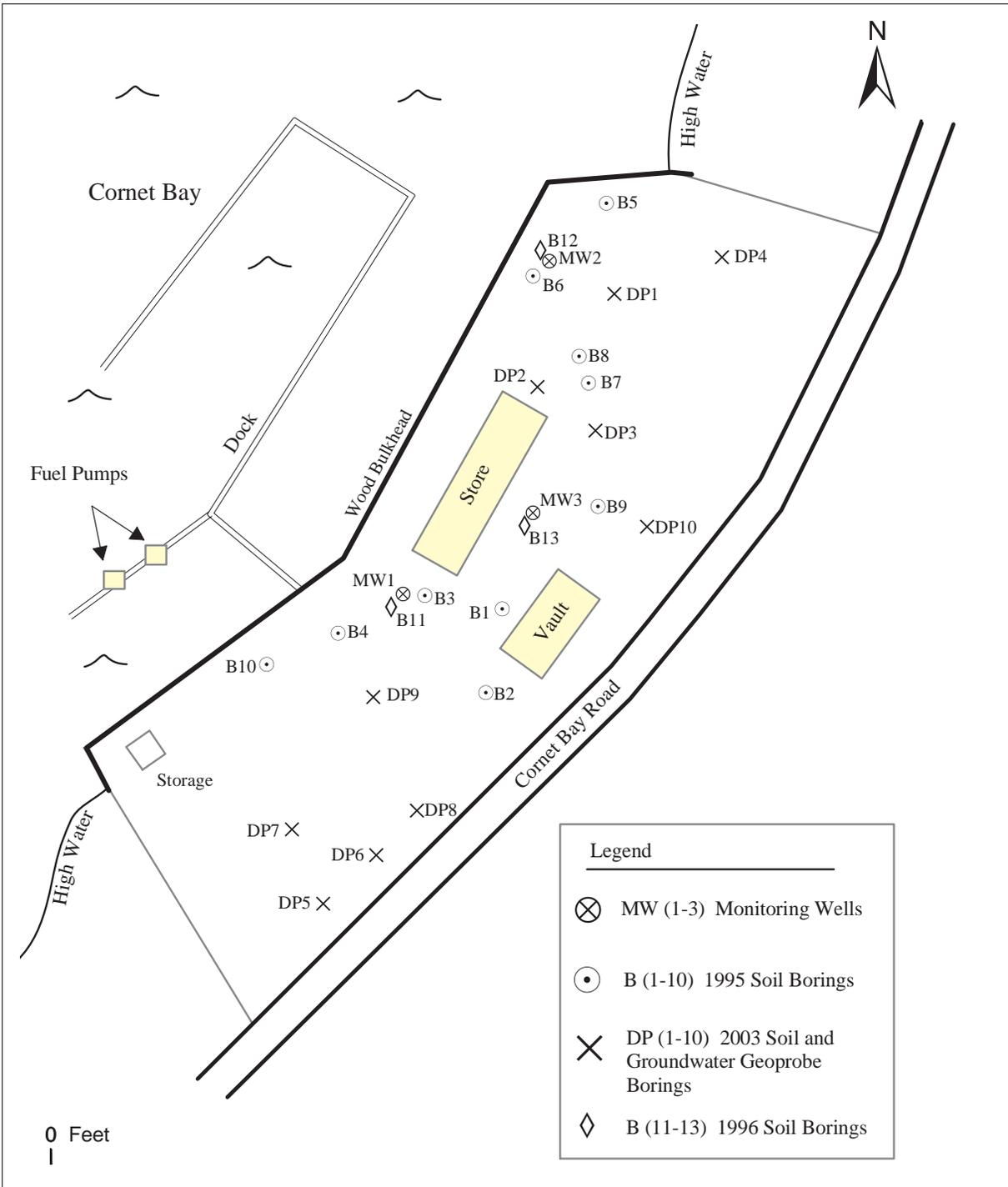


Figure A-1. Sampling locations for Groundwater and Soil at Cornet Bay Marina, 1995, 1996, and 2003.

Table A-1. Soil Borings Data from Ecology, 1995 and 1996.

Bore Hole Number	Date	Monitoring Well Location	Sample Depth	PID Readings	Benzene	Toluene	Ethylbenzene	Xylenes	GRO ¹	DRO ²	Lead
			(feet)	(ppm)	(ug/Kg) dw				(mg/Kg) dw		
B-1	Nov-95	---	2.5-3.5	1	547 J	<273	<273	<1363	13	50	---
			6.2-7.2	740	2630	177 J	2040	9090	380	670	---
B-2	Nov-95	---	2.5-3.8	450	10300	55600 E	18800	99700 E	1300	53	---
			5.0-6.2	20	352 J	617	506	2902	110	63	---
B-3	Nov-95	---	2.5-3.7	1200	6290	9710	43600 E	21960 E	4900	4030	---
			4.2-5.4	450	759 J	386 J	732	2541 J	47	63	---
B-4	Nov-95	---	2.5-3.7	3	347 J	<204	<204	220 J	12	51	---
			5.0-6.2	10	---	---	---	---	---	---	---
			12-13.2	20	<529	<264	<264	268 J	11	59	---
B-5	Nov-95	---	2.5-3.7	0	---	---	---	---	---	---	---
			6.0-7.2	50	3250	532	23900 E	98900 E	990	2300	---
B-6	Nov-95	---	2.5-3.7	4	<464	<232	<232	338 J	11	57	---
			4.5-5.7	0	---	---	---	---	---	---	---
			7.2-8.4	7	2100	<588	83 J	<1203	13	48	---
B-7	Nov-95	---	2.6-3.8	5	---	---	---	---	---	---	
B-8	Nov-95	---	3.0-4.2	925	4440	44000	23100	118700	2200	7400	---
			5.5-6.7	585	35500	5280	44900	208100 E	2600	2700	---
B-9	Nov-95	---	2.5-3.7	175	656 J	870 J	2450	12760	260	180*	---
			4.5-5.7	60	668 J	nd	4930	15460 J	620	1470	---
B-10	Nov-95	---	2.7-3.9	14	nd	nd	nd	nd	11	58	6
			5.5-6.7	2	nd	nd	nd	nd	13	64	5
B-11	Oct-96	MW-1	15.0	---	nd	nd	nd	nd	nd	nd	5
			30.0	---	nd	nd	nd	nd	nd	nd	nd
B-12	Oct-96	MW-2	5.0	---	790	160	2300	1880	440	870	3
			10.0	---	340	nd	66 J	49 J	nd	nd	3
			15.0	---	590	nd	nd	nd	nd	nd	4
B-13	Oct-96	MW-3	10.0	---	96J	42 J	440	1430 J	100	110	4
			15.0	---	98J	29 J	300	935	92	160	7
			20.0	---	nd	nd	nd	nd	nd	nd	nd

* value is an estimate, small fraction may represent gasoline

E - reported result is an estimate because it exceeds the calibration

J - analyte was positively identified, the associated numerical value is an estimate

< - analyte was not detected at or above the reported value

PID - photoionization detector

nd - not detected

-- no data

¹ Gasoline Range Organics

² Diesel Range Organics

Table A-2. Soil Borings Data from Geoprobe Explorations, Collected by Pinnacle GeoSciences, June 2003 (mg/Kg).

Bore Hole Number	Sample Depth (feet)	Benzene	Toluene	Ethyl-benzene	Xylenes	GRO ¹	DRO ²	HO ³	MTBE ⁴
DP-1	3.0	0.0901	0.0500 U	0.124	0.239	13.8	108	32.3	0.100 U
	5.0	4.29	0.949	39.3	22.2	2730	7050	1000 U	1.0 U
DP-2	5.0	0.260	0.0612	0.175	0.795	7.67	13.4	25.0 U	0.100 U
DP-3	3.0	0.300 U	0.500 U	9.25	3.36	769	1850	250 U	1.0 U
DP-4	3.0	0.0668	0.100 U	1.46	1.30	173	98.9	25.0 U	0.200 U
DP-5	3.0	10.7	202	47.6	219	5150	158	54.9	2.0 U
	5.0	1.26	2.21	0.728	4.02	44.7	16.8	27.6	0.100 U
DP-6	5.0	0.594	0.0960	0.146	0.584	5.0 U	16.6	38.9	0.100 U
DP-7	5.0	0.164	0.0500 U	0.100	0.100 U	5.0 U	10.0 U	25.0 U	0.100 U
DP-8	5.0	0.643	0.0991	0.700	3.32	41.3	23.6	37.4	0.100 U
DP-9	5.0	5.88	1.40	25.8	54.8	1910	5170	1000 U	2.0 U
DP-10	5.0	4.89	2.50 U	10.4	40.1	5310	73.4	25.0 U	5.0 U

U - not detected at or above the specified concentration

¹ Gasoline Range Organics

² Diesel Range Organics

³ Heavy Oils

⁴ Methyl tert-butyl ether

Table A-3. Groundwater Data from Ecology, 1996 and 2003, and GeoSciences, 2003 (ug/L).

Sample Location Name	Date	Benzene	Toluene	Ethyl-benzene	Xylenes	GRO ¹	DRO ²	HO ³	MTBE ⁴	Lead	Product Present?
Ecology Monitoring Well Data											
MW-1	Oct-96	nd	nd	nd	nd	nd	nd	---	---	2.4	---
MW-2	Oct-96	16400	23	170	98	1900	nd	---	---	2.2	---
MW-3	Oct-96	8500	130	1300	3400	24000	98000	---	---	9.9	---
Pinnacle GeoSciences Monitoring Well Data											
MW-1	Jun-03	0.5 U	0.5 U	0.5 U	1.0 U	50 U	294	500 U	1.0 U	---	No
MW-2	Jun-03	9000	50 U	354	100 U	21300	127000	10000 U	100 U	---	Yes
MW-3	Jun-03	185	4.63	86.7	29.4	1170	17200	500 U	3.91	---	No
Pinnacle GeoSciences GeoProbe Data											
DP-1	Jun-03	276	5.58	75.2	23.6	1220	739	500 U	8370	---	---
DP-2	Jun-03	7410	34.6	72.6	39.2	20100	4570	758	25000 U	---	---
DP-3	Jun-03	84.8	3.22	56.7	10.3	689	1190	500 U	5820	---	---
DP-4	Jun-03	22.9	2.04	97.1	43.8	930	445	500 U	2050	---	---
DP-5	Jun-03	803	358	3.13	27.5	1280	343	500 U	2040	---	---
DP-7	Jun-03	2390	7.09	24.5	10.4	5740	380	500 U	1000 U	---	---
DP-8	Jun-03	2390	781	348	2210	12800	1310	500 U	50000 U	---	---
DP-9	Jun-03	15700	103	613	820	40700	2860	500 U	37600	---	---
DP-10	Jun-03	27.9	3.23	23.1	91.5	2060	763	500 U	6240	---	---

--- not analyzed

U - analyte not detected at or above reported result

nd - not detected

¹ Gasoline Range Organics

² Diesel Range Organics

³ Heavy Oils

⁴ Methyl tert-butyl ether

Appendix B. Data Quality Assessment

Groundwater Sample Results

TPH-Dx

The surrogate recoveries for samples 05174096 and 05174097 could not be determined due to the large dilutions that were necessary for these samples. The Practical Quantitation Limit (PQL) for sample 05174095 was raised, and a “UJ” qualifier was added due to the presence of gasoline in the sample. The value reported was slightly above the amount of diesel that the product would represent if it was integrated as diesel. Since it represents a positive interference, diesel below this level could not be determined.

Surface Water Sample Results

PAH

For continuing calibration, phenanthrene and benzo(k)fluoranthene displayed an increase in response indicating a high bias. All positive detects for these compounds were qualified “J”. Benzo(b)fluoranthene and benzo(k)fluoranthene experienced chromatographic problems, and their peaks could not be resolved. As a result, half the peak was assigned to benzo(b)fluoranthene and the other half to benzo(k)fluoranthene. Results for both compounds were qualified “J”.

Sediment Sample Results

BTEX

No target analytes were detected in the method blank, with the exception of ethylbenzene and m & p xylene which were qualified with a “J”.

TPH-Dx

The PQL for sample 05174087 was raised, and a “UJ” qualifier was added due to the presence of an unknown material in the sample. The value reported was slightly above the amount of diesel that the product would represent if it was integrated as diesel. Since it represents a positive interference, diesel below this level could not be determined.

PAHs

Relative standard deviations were within the maximum 20% for the continuing calibration, except for phenanthrene and benzo(k)fluoranthene which had a high response on the May 11, 2005 calibration. Results for these two compounds were qualified as estimates “J” if detected. Both 1- and 2-methylnaphthalene were also high in the May 17 calibrations, but neither compound was reported in the dilutions.

The percent recoveries of the sample 05174081 matrix spike were within 50% to 150% after correction for the native amounts, except for naphthalene (49%) and phenanthrene, fluoranthene, and pyrene which could not be corrected due to the high native amounts present. These compounds are reported as not calculated “NC”.

Recoveries for the matrix spike duplicate were lower, and after correcting for the native naphthalene (33%), 2-methylnaphthalene (42%), acenaphthylene (35%), acenaphthene (11%), dibenzofuran (14%), fluorene (45%), benzo(a)anthracene (13%), and benzo(a)pyrene (26%) had low recoveries. Due to the native amount correction and the possible inhomogeneity of the sample, most of the Relative Percent Differences (RPDs) were outside the acceptable limits of less than 40% RPD (Table B-4). Because the recoveries are low in this sample, the contaminant levels are probably underestimated.

Sample 05174080 was analyzed as a laboratory duplicate (Table B-5). Most of the compounds were outside the RPD of 40% due to the inhomogeneity of the sample.

Two compounds, benzo(b)fluoranthene and benzo(k)fluoranthene, experienced chromatographic problems and their peaks could not be resolved. As a result, half the peak was assigned to benzo(b)fluoranthene and the other half to benzo(k)fluoranthene. All results where these two compounds were detected were qualified as estimates "J".

Duplicate Split Sample

Samples 05174082 and 05174087 were a duplicate split sample for sediments. The mean RPD for PAHs for these samples was 57%, which is above the acceptable level of 50% established in the Quality Assurance Project Plan for this study (Table B-8). The results for sample 05174087 were about 80% higher than for sample 05174082, suggesting a systematic error, but upon review of the data, Manchester confirmed the results.

Surrogate recoveries were similar between the two samples, with sample 05174082 varying between 65% and 100% (86% to 115% for the dilution), and sample 05174087 varying between 65% and 91% (71% to 101% for the dilution).

Grain size for the two samples was also similar, and the RPD for lead was acceptable in both samples.

Table B-1. Field Replicate Groundwater Results for BTEX, TPH-Gx, and TPH-Dx, 2005.

Station name:	CBMGW-3	CBMGW-3 (Rep)		RPD
Sample number:	5174096	5174097		
BTEX (ug/L)				
Benzene	260		270	4%
Ethylbenzene	91		97	6%
Toluene	10	U	10	U
m & p-Xylene	20	U	20	U
o-Xylene	10	U	10	U
			Mean:	5%
TPH-Dx (mg/L)				
#2 Diesel	31		7.6	121%
TPH-Gx (mg/L)				
Gasoline	1.4		1.3	7%

RPD - Relative percent difference

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

Table B-2. Results for Transfer and Pump Blanks, 2005.

Transfer Blank (sample 05174090)	Result	
BTEX (ug/L)		
Benzene	1	U
Ethylbenzene	1	U
Toluene	1	U
m & p-Xylene	2	U
o-Xylene	1	U
TPH-Gx (mg/L)		
Gasoline	0.14	U
Pump Blank (sample 05174094)	Result	
BTEX (ug/L)		
m & p-Xylene	2	U
Ethylbenzene	1	U
Toluene	1	U
Benzene	1	U
o-Xylene	1	U
TPH-Dx (mg/L)		
#2 Diesel	0.048	U
TPH-Gx (mg/L)		
Gasoline	0.14	U

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

Table B-3. Matrix Spike and Matrix Spike Duplicate Surface Water Results, 2005.

Analyte	Matrix Spike	Matrix Spike Duplicate	RPD of recovery
	% recovery		
PAHs			
Naphthalene	81	93	14%
Acenaphthylene	110	108	2%
Acenaphthene	103	101	2%
Fluorene	114	114	0%
Phenanthrene	118	98	19%
Anthracene	100	148	39%
2-Methylnaphthalene	111	104	7%
Total LPAH			
Fluoranthene	98	99	1%
Pyrene	96	85	12%
Benzo(a)anthracene	80	85	6%
Chrysene	87	91	4%
Benzo(b)fluoranthene	73	80	9%
Benzo(k)fluoranthene	75	115	42%
Benzo(a)pyrene	77	82	6%
Indeno(1,2,3-cd)pyrene	88	96	9%
Dibenzo(a,h)anthracene	90	94	4%
Benzo(ghi)perylene	95	100	5%
Total HPAH			
Other Non-ionizable Organic Compounds			
2-Chloronaphthalene	131	115	13%
Carbazole	146	101	36%
Dibenzofuran	117	110	6%
		Mean:	12%
Other			
Hardness as CaCO ₃	85	79.8	6%
Lead	109	107	2%

Matrix spike duplicate performed on sample 05174088

RPD - Relative percent difference

Table B-4. Matrix Spike and Matrix Spike Duplicate Sediment Results, 2005.

Analyte	Matrix Spike	Matrix Spike Duplicate	RPD of recovery
	% recovery		
BTEX (MEL sample number 05174080)			
Benzene	95	96	1%
Ethylbenzene	99	98	1%
m & p-Xylene	103	106	3%
o-Xylene	95	99	4%
Toluene	91	91	0%
PAHs (MEL sample number 05174081)			
Naphthalene	49	33	39%
Acenaphthylene	61	35	54%
Acenaphthene	65	11	142%
Fluorene	63	45	33%
Phenanthrene	NC	107	---
Anthracene	74	133	57%
2-Methylnaphthalene	64	42	42%
Total LPAH			
Fluoranthene	NC	NC	---
Pyrene	NC	NC	---
Benzo(a)anthracene	128	13	163%
Chrysene	141	NC	---
Benzo(b)fluoranthene	115	NC	---
Benzo(k)fluoranthene	85	NC	---
Benzo(a)pyrene	82	26	104%
Indeno(1,2,3-cd)pyrene	95	55	53%
Dibenzo(a,h)anthracene	81	58	33%
Benzo(ghi)perylene	95	56	52%
Total HPAH			
Other Non-ionizable Organic Compounds			
1-Methylnaphthalene	NAF	NAF	---
2-Chloronaphthalene	68	55	21%
Carbazole	55	79	36%
Dibenzofuran	51	14	114%
Retene	NAF	NAF	---
		Mean:	67%
TPH-Gx (MEL sample number 05174091)			
Gasoline	89	80	11%
Metals (MEL sample number 05174092)			
Lead	92.1	90.9	1%

RPD - Relative percent difference
 NAF - Not analyzed for
 NC - Not calculated

Table B-5. Lab Duplicate Sediment Results for PAHs and TPHs, 2005.

Station name:	CBMSED-1	CBMSED-1	RPD of lab duplicate (%)
Sample number:	05174080	05174080	
PAHs (ug/Kg) dw			
Naphthalene	80	125	44%
Acenaphthylene	28	46	49%
Acenaphthene	288	340	17%
Fluorene	218	312	35%
Phenanthrene	1610	J 4660	J 97%
Anthracene	256	384	40%
2-Methylnaphthalene	15	53	112%
Total LPAH			
Fluoranthene	4340	7980	59%
Pyrene	3490	6630	62%
Benzo(a)anthracene	404	662	48%
Chrysene	1750	2800	46%
Benzo(b)fluoranthene	369	J 687	60%
Benzo(k)fluoranthene	526	J 678	J 25%
Benzo(a)pyrene	235	350	39%
Indeno(1,2,3-cd)pyrene	119	190	46%
Dibenzo(a,h)anthracene	46	76	49%
Benzo(ghi)perylene	107	187	54%
Total HPAH			
Other Non-ionizable Organic Compounds			
1-Methylnaphthalene	111	138	22%
2-Chloronaphthalene	5.4	U 5.4	U ---
Carbazole	32	346	166%
Dibenzofuran	150	219	37%
Retene	46	832	179%
		Mean:	61%
	Sample	Lab Dup	
	CBMSED-4	CBMSED-4	
	05174083	05174083	
TPH-Gx (mg/Kg) dw			
Gasoline	9.3	U 9.2	U ---
	Sample	Lab Dup	
	CBMSED-2	CBMSED-2	
	05174081	05174081	
TPH-Dx (mg/Kg) dw			
#2 Diesel	18	U 18	U ---

RPD - Relative percent difference

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

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

Table B-6. Triplicate Analysis of Sediment Grain Size, Analytical Resources, Inc., 2005 (%).

Sediment Size Fraction	phi size	05174086	05174086 Dup1	05174086 Dup2	RSD of triplicate analysis
Total Solids	---	63.0	63.1	63.2	0%
Gravel	> -1	0.1	0.0	0.0	173%
Very Coarse Sand	-1 to 0	0.7	0.7	0.7	0%
Coarse Sand	0 to 1	4.8	4.7	4.6	2%
Medium Sand	1 to 2	13.7	13.8	13.8	0%
Fine Sand	2 to 3	10.7	11.1	10.6	2%
Very Fine Sand	3 to 4	10.4	10.3	10.1	1%
Coarse Silt	4 to 5	15.6	15.7	16.4	3%
Medium Silt	5 to 6	16.7	16.4	16.2	2%
Fine Silt	6 to 7	9.0	9.3	9.1	2%
Very Fine Silt	7 to 8	4.4	4.2	4.4	3%
Clay	8 to 9	3.1	3.1	3.4	5%
Clay	9 to 10	3.4	3.3	3.0	6%
Clay	< 10	7.3	7.3	7.5	2%

RSD – Relative standard deviation

Table B-7. Total Organic Carbon Triplicate Sediment Results, 2005 (%).

	Sample	Lab Dup	Lab Dup 2	RSD of lab triplicate
Station name:	CBMSED-2	CBMSED-2	CBMSED-2	
Sample number:	05174081	05174081	05174081	
Total Organic Carbon	0.41	0.44	0.56	5%

RSD – Relative standard deviation

Table B-8. Duplicate Split Sediment Results for Lead, TPHs, PAHs, and Other Compounds, 2005.

Sampling Station:	CBMSED-3	CBMSED-3 (dup)		RPD of	
Sample number:	05174082	05174087		duplicate split	
Metals (mg/Kg) dw					
Lead	3.61		4.07	12%	
Total Petroleum Hydrocarbons (mg/Kg) dw					
Gasoline	8.5	U	8.3	U	---
#2 Diesel	19	U	91	UJ	---
Non-ionizable Organic Compounds (Polynuclear Aromatic Hydrocarbons) (ug/Kg) dw					
Naphthalene	139		164		17%
Acenaphthylene	90		172		63%
Acenaphthene	702		832		17%
Fluorene	760		1380		58%
Phenanthrene	5900	J	10200	J	53%
Anthracene	1260		1600		24%
2-Methylnaphthalene	44		175		120%
Total LPAH	8851	J	14348	J	47%
Fluoranthene	12300		21100		53%
Pyrene	10400		19100		59%
Benzo(a)anthracene	1880		3440		59%
Chrysene	4030		7800		64%
Benzo(b+k)fluoranthene*	1741	J	4880	J	95%
Benzo(a)pyrene	657		1340		68%
Indeno(1,2,3-cd)pyrene	285		495		54%
Dibenzo(a,h)anthracene	134		247		59%
Benzo(ghi)perylene	255		437		53%
Total HPAH	31682	J	58839	J	60%
				Mean:	57%
Other Non-ionizable Organic Compounds (ug/Kg) dw					
1-Methylnaphthalene	118		175		39%
2-Chloronaphthalene	5.2	U	5.2	U	---
Carbazole	218		414		62%
Dibenzofuran	385		616		46%
Retene	5.2	U	5.2	U	---
				Mean:	49%
Volatile Monoaromatic Hydrocarbons (ug/Kg) dw					
Benzene	0.24	U	0.21	U	---
Toluene	0.24	U	0.21	U	---
Ethylbenzene	0.24	U	0.21	U	---
m & p-Xylene	0.47	U	0.43	U	---
o-Xylene	0.24	U	0.21	U	---
Other (%)					
Solids	75.6		76.1		1%
Total Organic Carbon	0.75		0.72		4%

RPD - Relative percent difference

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

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

UJ - Analyte was not detected at or above the reported estimated result.

Appendix C. Case Narratives

Data Qualifier Codes

- U - The analyte was not detected at or above the reported result.
- J - The analyte was positively identified. The associated numerical result is an estimate.
- UJ - The analyte was not detected at or above the reported estimated result.
- REJ- The data are unusable for all purposes.
- NAF- Not analyzed for.
- N - For organic analytes there is evidence the analyte is present in this sample.
- NJ - There is evidence that the analyte is present. The associated numerical result is an estimate.
- NC- Not calculated
- E - The concentration exceeds the known calibration range.
- bold-** The analyte was present in the sample. (Visual aid to locate detected compounds on report sheet.)

Manchester Environmental Laboratory
7411 Beach Dr E, Port Orchard, Washington 98366

Case Narrative

May 19, 2005

Subject: Cornet Bay Project

Sample(s): 05174080-97

Officer(s): Kristin Kinney

By: Bob Carrell

NWTPH-Gx Analysis

Analytical Method

The water samples and sediment samples, a sample duplicate, two laboratory control spikes and four matrix spikes and two method blank were analyzed by the NWTPH-Gx method which, in the case of water, involves purging a portion of the water of its volatile compounds, trapping the analytes then desorbing them to the inlet of a gas chromatograph (GC) where they are separated by the chromatographic column and determined by flame ionization detection (FID) for total gasoline. For soil/sediment a portion of the soil/sediment is extracted with methanol and a portion of that methanol is added to water and analyzed as above.

Holding Times

The samples were analyzed within the recommended sample holding times.

Calibration

The initial eleven point gasoline calibration used a linear fit which had a correlation coefficient of greater than 0.99 and no standard point varied from its true value by more than +/- 15%. The mid-range calibration check sample for target analytes was within +/- 15% of its true value at the beginning and end of the analyses.

Blanks

No analytically significant levels of analyte were detected in the method blank associated with this sample.

Surrogates

The surrogate recoveries were acceptable and within QC acceptance limits of 70% to 130% except for the 1,4-difluorobenzene in sample 05174096 (153%) and 05174097 (154%). Since there was considerable gasoline in these samples it is suspected that the surrogate values are high due to positive interference. Since the other surrogate recoveries were acceptable no qualifiers were added.

Sample Duplicate

The results of the sample duplicate were acceptable.

Laboratory Control Spikes

The results of the LCSs are acceptable.

Sample Matrix Spikes

The results of the matrix spikes are acceptable.

Manchester Environmental Laboratory
7411 Beach Dr E, Port Orchard, Washington 98366

Case Narrative

July 13, 2005

Revised

Subject: Cornet Bay Project

Sample(s): 05174080-89 and 05174091-97

Officer(s): Kristin Kinney

By: Bob Carrell

NWTPH-Dx Analysis

Analytical Method

These samples, two laboratory control spikes a sample duplicate and four method blanks were extracted with methylene chloride and analyzed by gas chromatography with flame ionization detection (GC/FID) as outlined in the NWTPH-Dx method.

Holding Times

The samples were extracted and analyzed with the recommended holding times.

Calibration

The nine point #2 diesel oil calibration using a linear fit resulted in correlation coefficient of greater than 0.99 and no standard varying from its true value by more than +/-15%. Also the beginning and end of analytical run check standards did not vary from their true value by more than +/- 15%.

Blanks

No analytically significant levels of analyte were detected in the method blanks associated with this sample.

Surrogates

The pentacosane surrogate recoveries were acceptable and within the QC limits of 50% to 150% except for samples 05174087 (177%), 05174091 (168%) and 05174092 (167%). Initially most of the samples from 05174080-87 showed recoveries which were twice what was reported however it is suspected that these samples may have been double spiked with surrogate. As such half those surrogate values were reported. Double spike or not, since no diesel or lube oil was found in any of those samples except sample 05174085 (and that had a concentration well below the regulatory level), since the LCS's indicated no quantitation problems and since a high bias would tend to detect petroleum products better, no qualifiers were added due to surrogate recoveries.

The surrogate recoveries for samples 05174096 and 05174097 could not be determined due to the large dilutions that were necessary for these samples, thus the 'NC' qualifier was used.

Sample Duplicate

The results of the sample duplicate were acceptable.

Matrix Spikes

None extracted.

Laboratory Control Spike

The results of the LCSs were acceptable.

Comments

The PQLs for samples 05174087 and 05174095 were raised and 'UJ' qualifiers were added due to the presence of an unknown material and gasoline respectively in those samples. The values reported were slightly above the amount of "diesel" that these two products would represent if these products were integrated as diesel. Since they present a positive interference diesel below these levels could not be determined.

Manchester Environmental Laboratory
7411 Beach Dr E, Port Orchard, Washington 98366

Case Narrative

May 19, 2005

Subject: Cornet Bay Project

Sample(s): 05174088-90 and 05174093-97

Officer(s): Kristin Kinney

By: Bob Carrell

BTEX Analyses

Analytical Method

The water samples, a BTEX laboratory control spike and three method blanks were purged, the analytes trapped then desorbing into the inlet of a gas chromatograph (GC) where they are separated by the chromatographic column and determined by photoionization detection (PID) for BTEX.

Holding Times

The samples were analyzed within the accepted holding times.

Calibration

The initial eight point BTEX calibrations used linear fit which had correlation coefficients of greater than 0.99 and no standard point varied from its true value by more than +/- 15%. The daily calibration verification analysis at the beginning of the analytical run and at the end of the run did not vary from their true values by more than +/- 15%.

Blanks

No analytically significant levels of analyte were detected in the method blank associated with this sample.

Surrogates

The surrogate recoveries were acceptable and within QC acceptance limits of 70% to 130% except for the 1,4-dibromo-2-methyl benzene surrogate for samples 05174089 (145%),

05174096 (152%) and 05174097 (142%). Since the results of the other surrogate were acceptable, no qualifiers were added.

Sample Duplicates

None analyzed.

Laboratory Control Spikes

The results of the LCS were acceptable.

Manchester Environmental Laboratory
7411 Beach Dr E, Port Orchard, Washington 98366

Case Narrative

May 09, 2005

Subject: Cornet Bay

Project No: 128805

Sample No: 05174080 – 05174087; 05174091, 05174092

Officer: Kristin Kinney

By: Dolores Montgomery

Summary

The samples were analyzed using EPA method 8260 for volatile organic analysis (VOA).

All analyses requested were evaluated by established regulatory quality assurance guidelines.

Holding Times

All samples were analyzed within the method holding times.

Tuning

Calibration against bromofluorobenzene (BFB) is acceptable for the initial calibration, continuing calibration and all associated sample analyses. The matrix spike and matrix spike duplicate were analyzed slightly beyond the 12 hour calibration limit. No data qualifiers were assigned on this basis.

Initial Calibration

All compounds met established QC guidelines.

Continuing Calibration

All compounds were within established QC limits.

Method Blanks

No target analytes were detected in the method blank with the exception of ethylbenzene and m & p xylene. If the amount of either target analyte present in the associated samples was less than the reporting limit and less than ten times the amount found in the method blank, it was reported not detected at the reporting limit without qualification. If the amount present in the associated samples was greater than the reporting limit but less than ten times the amount found in the method blank, it was reported not detected at the level detected and qualified UJ, estimated value. If the amount present in the associated samples was greater than ten times the amount found in the method blank, it is considered native to the sample and reported without qualification.

Matrix Spikes

A matrix spike was performed on sample 04174080. All compound recoveries and RPD's fell within established guidelines.

Laboratory Control Sample

No laboratory control sample was analyzed with the sample set.

Surrogates

All surrogates fell within established QC limits.

Internal Standards

All internal standards fell within established QC limits.

Manchester Environmental Laboratory
7411 Beach Dr E, Port Orchard, Washington 98366

Case Narrative

June 1, 2005

Subject: Cornet Bay

Sample(s): 05-174080 to -174087, -174091 and -174092

Officer(s): Kristen Kinney

By: Dickey D. Huntamer

Semivolatiles

PAH's

Analytical Method(s)

These samples were analyzed by SW846 Method 8270 using capillary GC and a mass spectrometer detector. The extracts were cleaned up using silica gel for the PAH's, EPA Method 3630B.

Holding Times

All samples were prepared and analyzed within the method holding times.

Instrument Tuning

Calibration against DFTPP is acceptable for the initial calibration, continuing calibration and all associated sample analyses.

Calibration

The average relative response factors for target analytes were above the minimums and % Relative Standard Deviations were within the maximum of 15% for the initial calibration.

The average relative response factors for target analytes were above the minimums and % Relative Standard Deviations were within the maximum 20% for the continuing calibration except for phenanthrene and benzo(k)fluoranthene which had a high response on the May 11th calibration. Results for phenanthrene and benzo(k)fluoranthene were qualified as estimates "J" if detected. Both 1 and 2-methylnaphthalene were also high in the May 17th calibrations but neither compound was reported in the dilutions.

Blanks

No target compounds were detected in the laboratory blanks.

Surrogates

The surrogate recoveries were reasonable, acceptable, and within QC limits of 23% to 120% for d5-nitrobenzene, 18% to 137% for d14-terphenyl, and 50% to 150% for d10-pyrene.

Matrix Spikes

Aliquots of sample -174081 were analyzed as matrix spikes.

The percent recoveries of the -174081 LMX1 were within 50% to 150% after correction for the native amounts except for phenanthrene, fluoranthene and pyrene which could not be corrected due to the high native amounts present are reported as not calculated "NC". Recoveries for the matrix spike duplicate 174081 LMX2 were lower and after correcting for the native naphthalene (33%), 2-methylnaphthalene (42%), acenaphthylene (35%), acenaphthene (11%), dibenzofuran (14%), fluorene (45%), benzo(a)anthracene (13%) and benzo(a)pyrene (26%) had low recoveries. Due to the native amount correction and the possible inhomogeneity of the sample most of the Relative Percent Differences (RPD) were outside the acceptable limits of less than 40% RPD.

Replicates

Sample -174080 was analyzed in duplicate. Most of the compounds were outside the Relative Percent Difference (RPD) of 40% due to the inhomogeneity of the sample. The dilution for -174080 is DIL1 and the dilution for -174080 duplicate is DIL2.

Laboratory Control Samples

Recovery data for the Lab Fortified Blank, OL05122S1 were within the QC limits of 50% to 150% except for acenaphthylene (13%), anthracene (23%), carbazole (29%) and benzo(a)pyrene (22%) which were low. Since the recoveries of these compounds in the matrix spikes were acceptable or high no qualifiers were added to the results.

Comments

Two compounds, benzo(b)fluoranthene and benzo(k)fluoranthene experienced chromatographic problems and their peaks could not be resolved. As a result half the peak was assigned to benzo(b)fluoranthene and the other half to benzo(k)fluoranthene.

All results where benzo(b)fluoranthene and benzo(k)fluoranthene were detected were qualified as estimates "J".

Manchester Environmental Laboratory
7411 Beach Dr E, Port Orchard, Washington 98366

Case Narrative

May 23, 2005

Subject: Cornet Bay

Project No: 128805

Sample No: 05174088 - 05174089

Officer: Kristin Kinney

By: Dolores Montgomery

Summary

The samples were analyzed using EPA method 8270 for PAHs.

All analyses requested were evaluated by established regulatory quality assurance guidelines.

Holding Times

All samples were analyzed within the method holding times.

Tuning

Calibration against DFTPP is acceptable for the initial calibration, continuing calibration and all associated sample analyses.

Initial Calibration

All compounds had average response factors with %RSD < 15%, linear correlation coefficients of greater than 0.995, or a coefficient of determination greater than 0.99.

Continuing Calibration

The following compounds displayed an increase in response indicating a high bias: phenanthrene and benzo(k)fluoranthene All positive detects were qualified J.

Method Blanks

No target analytes were detected in the method blanks.

Matrix Spikes

Sample 05174089 was utilized for a matrix spike / matrix spike duplicate. All recoveries and RPD's were within established QC guidelines.

Laboratory Control Samples

Recoveries for the LCS were within acceptance criteria.

Surrogates

All surrogates fell within established QC limits.

Internal Standards

All internal standards fell within established QC limits.

Comments

Two compounds, benzo(b)fluoranthene and benzo(k)fluoranthene experienced chromatographic problems and their peaks could not be resolved. As a result, half the peak was assigned to benzo(b)fluoranthene and the other half to benzo(k)fluoranthene based on the chromatography. Due to the uncertainty in this assignment results for both compounds were qualified "J".

Manchester Environmental Laboratory
7411 Beach Dr E, Port Orchard, Washington 98366

Case Narrative

May 10, 2005

Subject: Cornet Bay Project

Sample(s): 05174080-89, 05174091-93 and 05174095-96

Officer(s): Kristin Kinney

By: Bob Carrell

Hydrocarbon Identification Analysis

Analytical Method(s)

Portions of these samples were extracted with methylene chloride then analyzed, along with a method blank and various petroleum product standards, by gas chromatography with flame ionization detection (GC/FID). This method is consistent with a modified EPA SW-846 Method 8015B and/or ASTM Method D-3328.

Holding Times

The samples were extracted and analyzed within the recommended method holding times.

Calibration

This is not applicable in the traditional sense since only various petroleum products standards are analyzed to establish chromatographic product “fingerprints”.

Blanks

No analytically significant levels of any petroleum product or hydrocarbon were detected in the method blank associated with these samples.

Comments

The HCID analysis showed that samples 05174080-85 and 05174091 contained weathered coal tar creosote as evidenced by the presence of the PAHs fluoranthene and pyrene. Sample 05174085 also contained a lube oil.

Samples 05174086-89 and 05174092-93 did not contain any recognizable compounds or products but compounds were present to varying degrees. Samples 05174095 contained weathered gasoline and sample 05174096 contained either weathered #2 diesel or #2 fuel oil (red diesel), which are typically identical chromatographically.

Manchester Environmental Laboratory
7411 Beach Drive E, Port Orchard, Washington 98366

Case Summary
July 13, 2005

Project: Cornet Bay
Samples: 17-4080-87,91-92
Laboratory: Analytical Resources, Inc.
By: Pam Covey

These ten (10) sediment samples required Grain Size analyses using Puget Sound Estuary Protocol (PSEP) method. The samples were received at the Manchester Environmental Laboratory and taken to the contract lab on May 2, 2005 for Grain Size analyses.

The analyses were reviewed for qualitative and quantitative accuracy, validity and usefulness. One sample (17-4086) was analyzed in triplicate and was within QA requirements.

If you have any questions, please call me.

Manchester Environmental Laboratory
7411 Beach Dr E, Port Orchard, Washington 98366

Case Narrative

May 21, 2005

Subject: Metals Cornet Bay

Project No: 128805

Officer: Kristin Kinney

By: Dean Momohara

Summary

The samples were analyzed and/or digested using the following methods: EPA method 200.7 (ICP) for the analysis of hardness, Standard Methods 2340B for the algorithm used for the hardness calculation, EPA method 3050B (solids) and 200.8 (liquids) for the digestion of metals and EPA method 200.8 (ICPMS) for the analysis of trace metals.

All analyses requested were evaluated by established regulatory quality assurance guidelines.

Sample Information

Samples were received by Manchester Environmental Laboratory on 4/28/05. All coolers were received within the proper temperature range of 0°C - 6°C. The samples were received in good condition. Liquid samples were received unpreserved and were preserved and filtered upon receipt. Twelve (12) samples were received and assigned laboratory identification numbers 174080 – 174089, 174091 and 174092.

Holding Times

All analyses were performed within established EPA holding times.

Calibration

Instrument calibrations and calibration checks were performed in accordance with the appropriate method. All initial and continuing calibration checks were within control limits. ICPMS calibration correlation coefficients were within the acceptance range of 1.000 - 0.995. The instruments were calibrated with NIST traceable standards and verified to be in calibration with a second source NIST traceable standard. Soil drying oven temperatures were recorded before and after each analysis batch and were within acceptable limits.

Method Blanks

No analytically significant levels of analyte were detected in the method blanks associated with these samples.

Matrix Spikes

All matrix spike recoveries were within the acceptance limits of 75% - 125%.

Replicates

All duplicate relative percent differences of samples with concentrations greater than 5 times the reporting limit were within the acceptance range of 0% - 20%.

Laboratory Control Samples

All laboratory control sample recoveries were within the acceptance limits of 85% - 115%.

Other Quality Assurance Measures and Issues

All internal standard recoveries were within acceptance limits.

Please call Dean Momohara at (360) 871-8808 to further discuss this project.

cc: Project File

Manchester Environmental Laboratory
7411 Beach Dr E, Port Orchard, Washington 98366

Case Narrative

May 23, 2005

Subject: General Chemistry Cornet Bay

Project No: 128805

Officer: Kristen Kinney

By: Dean Momohara

Summary

The samples were analyzed by the following method: PSEP - TOC for total organic carbon (TOC).

The analysis requested was evaluated by established regulatory quality assurance guidelines.

Sample Information

Samples were received by Manchester Environmental Laboratory on 4/28/05. All coolers were received within the proper temperature range of 0°C - 6°C. All samples were received in good condition. Ten (10) samples were received and assigned laboratory identification numbers 174080 – 174087, 174091 and 174092.

Holding Times

All analyses were performed within established EPA holding times.

Calibration

Instrument calibrations and calibration checks were performed in accordance with the appropriate method. All initial and continuing calibration checks were within control limits. The calibration correlation coefficient was within the acceptance range of 1.000 - 0.995.

Method Blanks

No analytically significant levels of analyte were detected in the method blanks associated with these samples.

Matrix Spikes

NA

Replicates

All duplicate relative percent differences were within the acceptance range of 0% - 20%.

Laboratory Control Samples

All laboratory control sample recoveries were within the acceptance limits of 54% - 144%.

Please call Dean Momohara at (360) 871-8808 to further discuss this project.

cc: Project File