

CALIFORNIA REGIONAL WATER  
JUN 02 1999  
QUALITY CONTROL BOARD

# **Sediment Investigation at Yosemite Creek**

**Fall 1998**

**Draft Report to:**

**City and County of San Francisco Public Utilities Commission, SPARC**

**Submitted to:**

**San Francisco Bay Regional Water Quality Control Board**

**May 1999**

Arthur D. Little, Inc.  
San Diego, CA  
92024, USA

Reference: 49484.00

# TABLE OF CONTENTS

<b>1.0 INTRODUCTION</b>	1-1
1.1 Purpose of Report	1-1
1.2 Site Description and Background Conditions	1-3
1.2.1 Stormwater and Sewer System	1-7
1.3 Historical Data	1-7
1.3.1 BPTCP Studies	1-8
1.3.2 Navy Studies	1-8
<b>2.0 SEDIMENT INVESTIGATION</b>	2-1
2.1 Sampling Design	2-1
2.2 Field Methods	2-4
2.2.1 Vessel Operations and Navigation	2-4
2.2.2 Pre-sampling Preparation	2-4
2.2.3 Sediment Sample Collection	2-4
2.2.4 Sample Tracking, Storage and Shipping	2-5
2.3 Laboratory Methods	2-6
2.3.1 Grain size and total organic carbon (TOC)	2-6
2.3.2 Metals	2-7
2.3.3 Polycyclic Aromatic Hydrocarbons (PAH) and Linear Alkyl-Benzenes (LAB)	2-7
2.3.4 Total Petroleum Hydrocarbons (TPH)	2-9
2.3.5 Chlorinated pesticides and polychlorinated biphenyls	2-10
2.3.6 10-day Solid Phase Amphipod Bioassay	2-11
2.4 Sample Archival	2-12
2.5 Data Management and Analysis	2-12
2.5.1 Data Transformations	2-12
2.5.2 Descriptive Statistics	2-12
2.5.3 Correlation Analysis	2-12
2.5.4 Regression Analysis	2-13
<b>3.0 GRAIN SIZE AND TOTAL ORGANIC CARBON</b>	3-1
3.1 Grain Size	3-2
3.2 Total Organic Carbon	3-4
<b>4.0 TOXICITY</b>	4-1
4.1 Background and Previous Results	4-1
4.1.1 SFPUC Tests	4-1
4.2 SFPUC Toxicity Results	4-2
4.2.1 Relationship of toxicity to sediment TOC and grain size	4-2

<b>5.0</b>	<b>CHEMICAL CONTAMINATION</b> .....	5-1
5.1	Metals .....	5-1
5.1.1	Surface sediments .....	5-1
5.1.2	Subsurface sediments .....	5-3
	Figure 5-3. Concentrations of mercury for each depth at Yosemite Creek subsurface stations.....	5-6
5.1.3	Source identification of elevated metals.....	5-7
5.2	Polycyclic aromatic hydrocarbons (PAH) .....	5-7
5.2.1	Surface sediment results .....	5-7
5.2.2	Subsurface sediment results .....	5-8
5.2.3	Source identification of PAH .....	5-8
5.3	Organochlorine Pesticides .....	5-8
5.3.1	DDT.....	5-9
5.3.2	Chlordane .....	5-9
5.3.3	Dieldrin.....	5-9
5.4	Polychlorinated biphenyls (PCB) .....	5-10
5.4.1	Surface sediment results .....	5-10
5.4.2	Subsurface sediment results .....	5-14
5.4.3	Source identification of PCB .....	5-14
<b>6.0</b>	<b>TOXIC HOT SPOT EVALUATION</b> .....	6-1
<b>7.0</b>	<b>REFERENCES</b> .....	7-1

**SECTION 1**

**INTRODUCTION**

# 1.0 INTRODUCTION

This report presents the results, conclusions, and recommendations of the sediment investigation conducted from March 1998 through May 31, 1999 at Yosemite Creek and nearby southwest Hunter's Point shoreline, located in San Francisco Bay, California. The investigation was performed by Arthur D. Little, Inc. (ADL) on behalf of the City and County of San Francisco, Public Utilities Commission (SFPUC). Sediment data were analyzed by SFPUC, Pacific EcoRisk, and ADL laboratories.

The scope of this investigation follows that presented in the project Sampling and Analysis Plan (ADL 1998), first submitted to the San Francisco Bay Regional Water Quality Control Board (SFRWQCB) as a draft in October 1998, and finalized in January 1999. The Sampling and Analysis Plan was responsive to the SFRWQCB's Section 13276 letter of June 1998 and subsequent letters of August and September, 1998 that further defined the requirements for collection and analysis of sediment data.

## 1.1 Purpose of Report

The purpose of this report is to document the results, findings, and conclusions of the sediment investigation to assess potential contamination and associated toxicity in surficial sediments of Yosemite Creek. The conclusions presented in this report will be used to determine whether Yosemite Creek has significant levels of contamination and sediment toxicity, and whether wet-weather runoff and combined sewer overflows (CSOs) into the creek present a possible significant source of contamination to the South Basin environment into which the creek enters (Figure 1-1). Data collected by the U.S. Navy in 1994 in support of a Phase I Remedial Investigation of the Hunter's Point Shipyard indicated significant levels of sediment contamination and toxicity in sediments from the South Basin (PRC 1996). Yosemite Creek was identified by the U.S. Navy as a possible source of contamination. To address this possibility, and to define the present condition of Yosemite Creek sediments, the SFPUC conducted a sediment sampling program in November 1998. Sediment toxicity tests were conducted and the chemical condition of sediments, both vertically and horizontally, was examined. Benthic organisms were collected and archived for possible future reference.

Specific objectives of this investigation were:

- To define the horizontal and vertical extent of contamination in Yosemite Creek
- If possible, to determine the extent that Combined Sewer Overflows (CSOs) contribute toxicity and/or contamination to the receiving creek beds;
- To collect and archive samples for possible additional analyses to support further investigation; and
- To identify type and quantity of additional data required to further assess the ecological health of creek sediments.
- To compare creek surface sediments with those from adjacent areas of the Naval Shipyard in the South Basin.

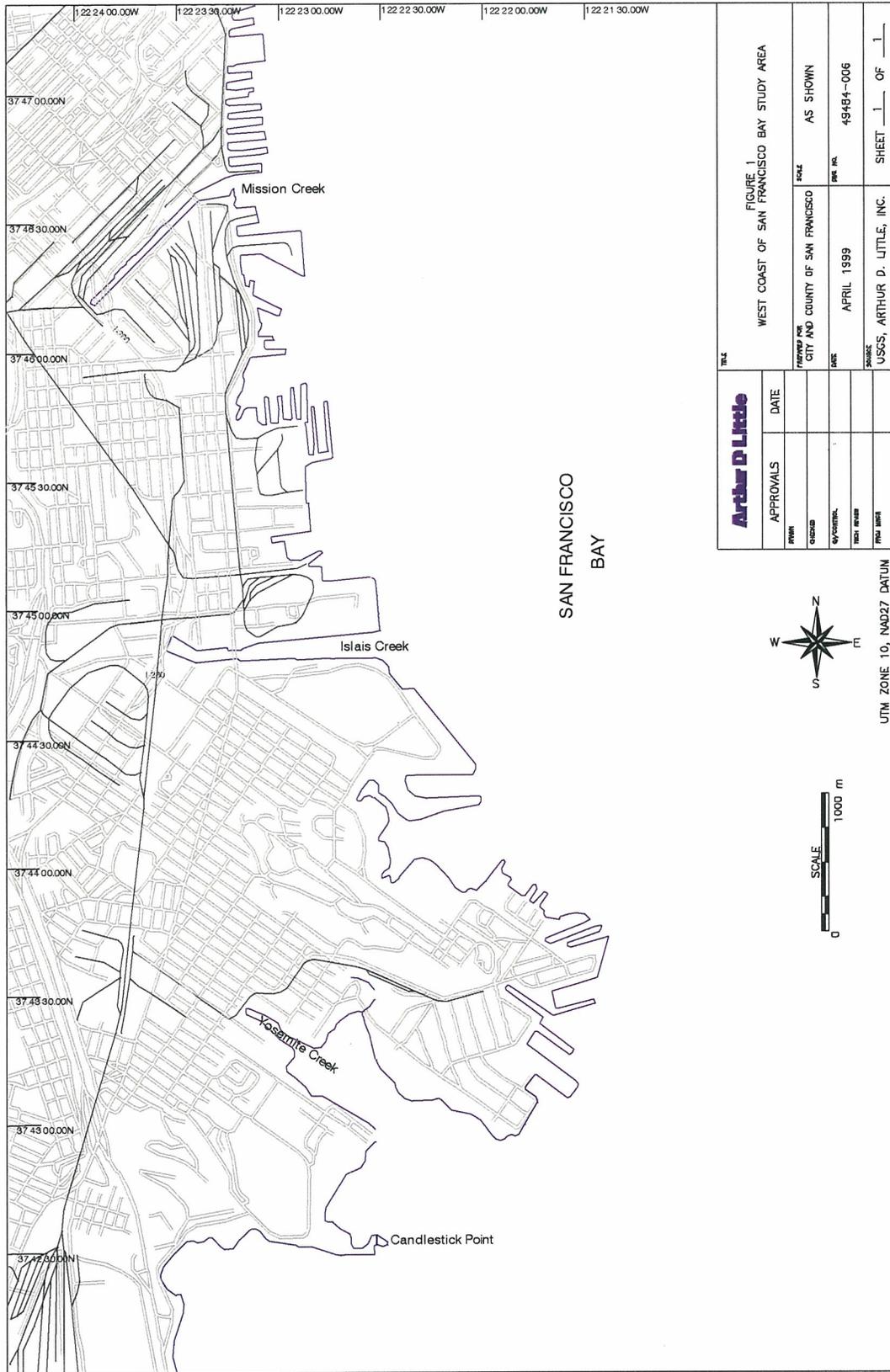


Figure 1-1. San Francisco Bay study area.

## 1.2 Site Description and Background Conditions

The Yosemite Creek Basin encompasses approximately 6000 acres of the southeast portion of San Francisco (Figure 1-1). The present creek channel extends only 500 m from its mouth, trending northwest and terminating at the stormwater CSO weir that was constructed in 1990. The present Yosemite Creek drainage basin is pictured in Figure 1-2. The creek enters into the South Basin which adjoins the southern shoreline of the Hunter's Point Naval Shipyard (Figures 1-1 and 1-2). This shoreline is undeveloped, consisting mainly of fill material. Available records indicate no historical dredging activity in the South Basin (PRC 1996).

Prior to the turn of the century, areas surrounding Yosemite Creek were mainly marshland or submerged below mean tide level. Most of this area was landfilled between 1940 and 1970. Fill material included crushed bedrock, construction debris and waste materials from the Navy Shipyard property, which began shipbuilding operations in 1941. By 1950, areas surrounding the creek were heavily utilized for residences, commercial business and small industry. The Navy port was an active center of secondary manufacturing for the shipyard from the 1940s to 1974. Within the last 15 years, industrial activities have primarily characterized the area surrounding the creek.

The SFPUC has researched available literature and records of land use activities surrounding Yosemite Creek, included a history of landfills and potential sources of contaminants from ground water, surface runoff, and combined sewer overflows into the creek. Potential sources of chemicals into the Yosemite Creek Basin watershed include the following:

1. Use of pesticides in greenhouse operations located west of Freeway 101, up through 1950. While this area is of considerable distance from the creek, it is a potential source of persistent compounds such as DDT that are presently found in creek sediments.
2. Use of pesticides, metals and PCBs in business and industrial operations from the drainage area east of Highway 101, which bisects the drainage basin (Figure 1-2). Major potential sources, based upon inventories of underground storage tanks, chemical releases, and hazardous waste generation include the properties of Bay Area Drum, Buckeye Properties and Gonzalez Bucket and Drum.
3. Historical usage of the adjacent Navy shipyard property (Hunter's Point; Figure 1-1) in which significant volumes of a wide range of chemicals have been potentially released into the watershed area outside the creek mouth. Groundwater and soil measurements along the creek length, and surrounding the South Basin from Candlestick Point to the south, and Hunter' Point Naval Shipyard to the north, indicate numerous sources of potential contaminant into the creek and adjacent bay sediments. Navy shipyard operations have discharged PCBs, petroleum hydrocarbons, trace metals and pesticides onto soils and into groundwater surrounding the South Basin. Operations included a former transformer storage yard, industrial landfills, fuel lines, a scrapyard, and oil reclamation area. Between 1954 and 1974, more than 7000 pounds of copper and lead and 250 gallons of PCBS were released in the scrapyard parcel that adjoins the South Basin. From 1944 to 1984, up to two million gallons per year of waste oil were processed at a reclamation facility that included unlined storage ponds, located on the southwest side of the shipyard, approximately 10 meters from the shoreline. An industrial landfill operation located near the mouth of Yosemite creek was used to dispose of solid and industrial wastes from the shipyard from 1958 through 1974.

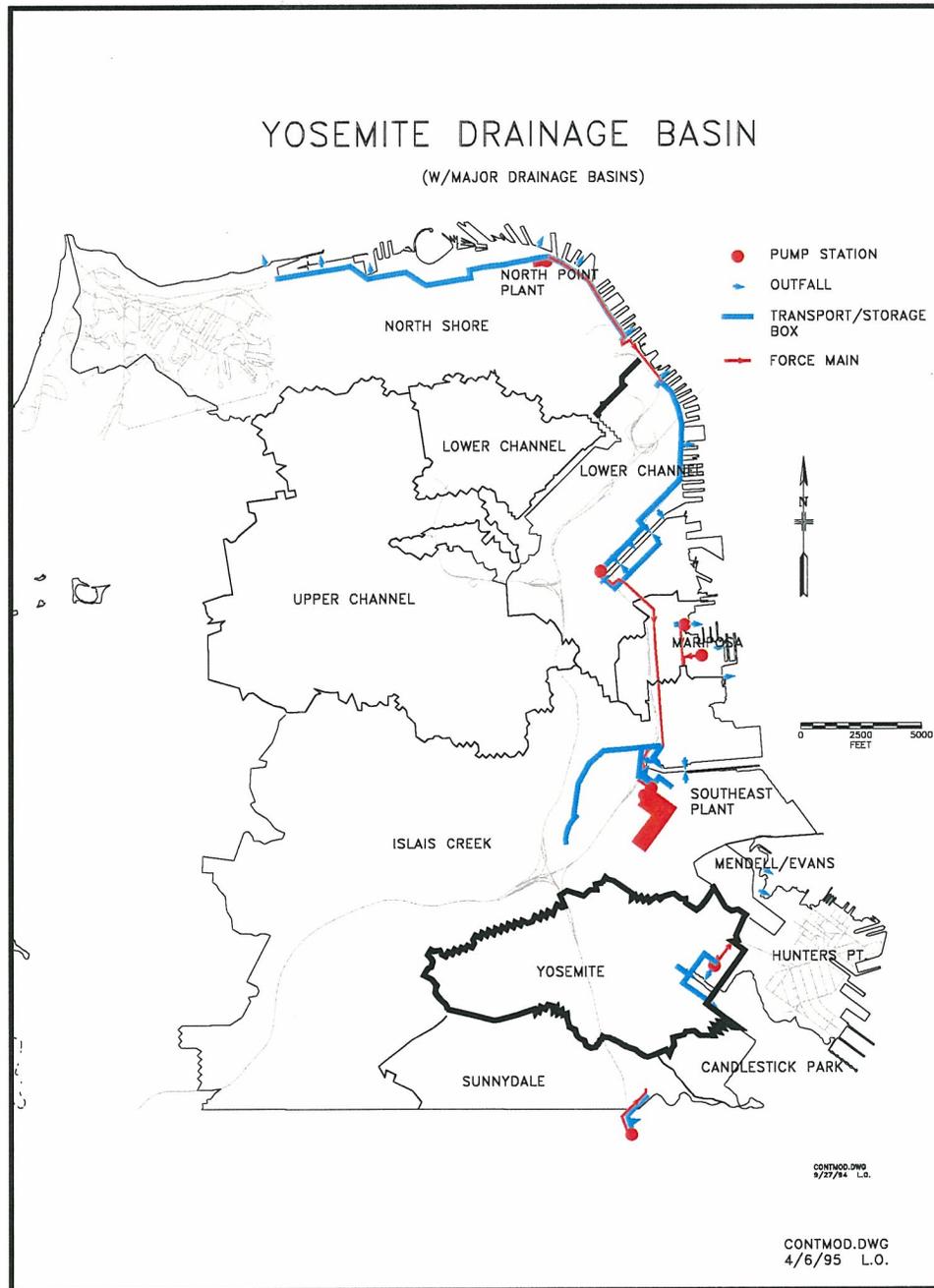


Figure 1-2. Drainage Basin of Yosemite Creek.

Due to wide ranging sources and duration of contaminant disposal into the Yosemite creek Basin and surrounding areas, significantly elevated concentrations of trace metals, pesticides, volatile organic compounds (VOCs) and petroleum hydrocarbons are encountered in soil and groundwater samples surrounding the creek. The eastern Yosemite Creek basin and adjacent shipyard present numerous pathways for introduction of contaminants into the creek area, including groundwater seepage, runoff and wind-borne particulates. Soil and groundwater chemical levels from areas surrounding the creek summarized in Figure 1-3.

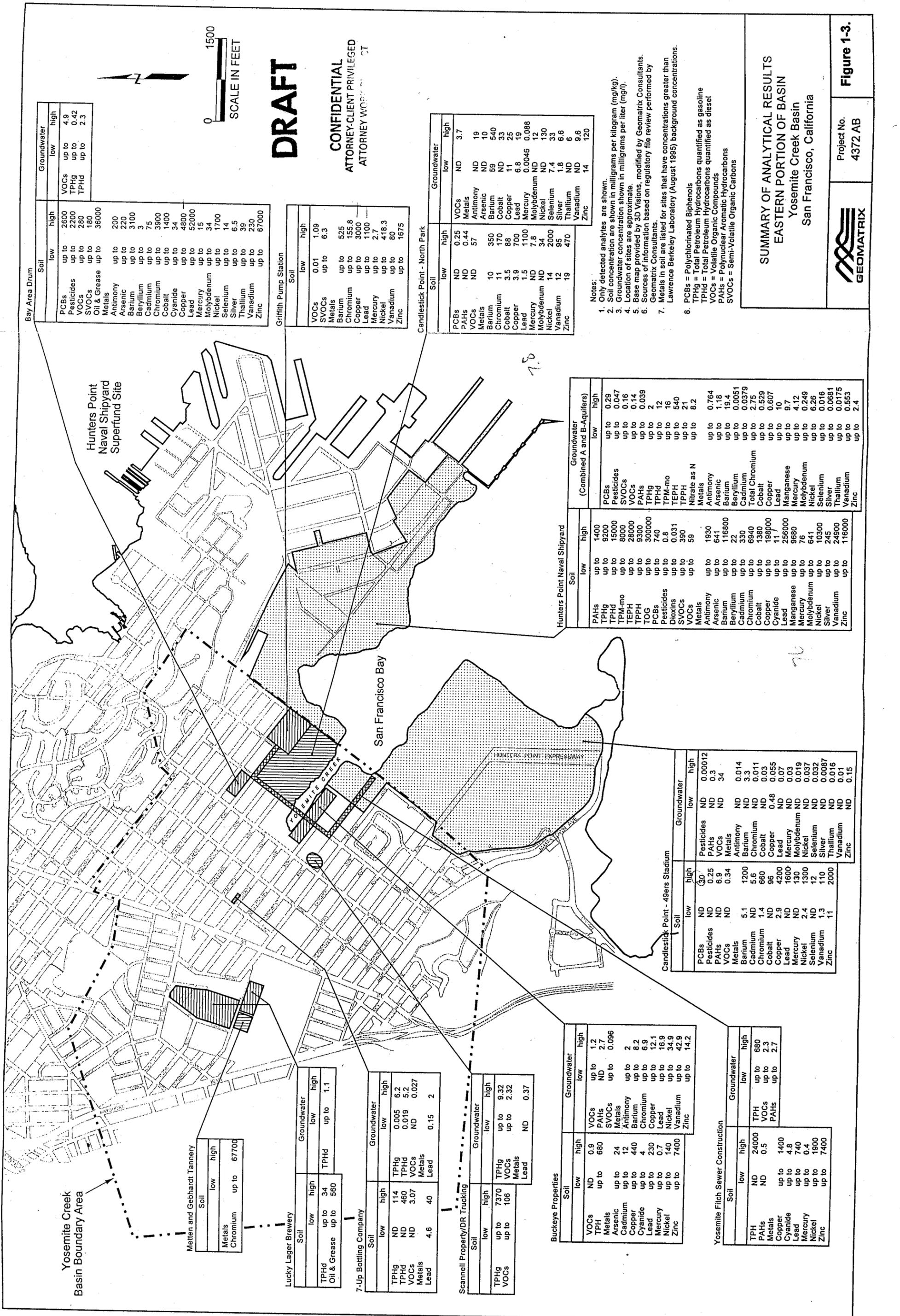
Exceptionally high metals (copper, lead, mercury) and PCB concentrations are evident from shipyard soils and groundwater, including PCBs at 740  $\mu\text{g/g}$ . Copper, mercury and zinc levels are elevated in Buckeye property soils, along the back two-thirds of the south shore of the creek. Groundwater in this area included elevated levels of xylene (1200  $\mu\text{g/L}$ ) and benzene (800  $\mu\text{g/l}$ ). Along the north shore, Candlestick Point-North Park soils show elevated lead and copper concentrations. PCBs were relatively low (250  $\mu\text{g/L}$ ). The Bay area drum property, located approximately 350 m north of the creek weir structure had PCB soil concentrations up to 2600 mg/Kg and similar pesticide levels. Highly elevated lead and zinc concentrations (>50,000 ppm) were also measured in this vicinity.

Maximum recorded concentrations from these areas for selected contaminants are presented in Table 1-1. These contaminants were listed by CRWQCB (1998) as pollutants that are present in Yosemite Creek sediments.

**Table1-1. Maximum reported soils concentrations of Yosemite Creek contaminants of concern.**

Chemical	Location	Maximum (mg/Kg)
PCBs	Bay Area Drum	2600
PAHs	Naval Shipyard	1400
DDT	Bay Area Drum	2200*
Chlordane	Not reported	
Dieldrin	Not reported	
Endrin	Not reported	
Tributly-tin	Not reported	
Copper	Candlestick Point	198,000
Lead	Naval Shipyard	256,000
Mercury	Candlestick Point	76
Zinc	Naval Shipyard	116,000

\*reported as "pesticides"



**DRAFT**  
**CONFIDENTIAL**  
 ATTORNEY-CLIENT PRIVILEGED  
 ATTORNEY WORK PRODUCT

Bay Area Drum

	Soil		Groundwater	
	low	high	low	high
PCBs	up to	2600	VOCs	up to
Pesticides	up to	2200	TPHg	up to
VOCs	up to	280	TPHd	up to
SVOCs	up to	180		4.9
Oil & Grease	up to	36000		0.42
				2.3

Hunters Point Naval Shipyard Superfund Site

Griffith Pump Station

	Soil	
	low	high
VOCs	0.01	1.09
Metals	up to	6.3
Barium	up to	525
Chromium	up to	155.8
Copper	up to	3000
Lead	up to	1100
Mercury	up to	2.7
Nickel	up to	418.3
Vanadium	up to	80
Zinc	up to	1675

Candlestick Point - North Park

	Soil		Groundwater	
	low	high	low	high
PCBs	ND	0.25	VOCs	ND
PAHs	ND	0.44	Metals	ND
VOCs	ND	57	Antimony	19
Metals			Arsenic	10
Barium	10	350	Barium	59
Chromium	11	170	Cobalt	33
Copper	3.5	88	Copper	25
Lead	3.9	700	Lead	6.8
Mercury	1.5	1100	Mercury	0.0046
Nickel	ND	7.8	Molybdenum	12
Molybdenum	ND	34	Nickel	ND
Nickel	14	2000	Selenium	7.4
Vanadium	12	95	Silver	1.8
Zinc	19	470	Thallium	ND
			Vanadium	ND
			Zinc	14
				120

- Notes:
- Only detected analytes are shown.
  - Soil concentration are shown in milligrams per kilogram (mg/kg).
  - Groundwater concentration shown in milligrams per liter (mg/l).
  - Location of sites are approximate.
  - Base map provided by 3D Visions, modified by Geomatrix Consultants.
  - Sources of information based on regulatory file review performed by Geomatrix Consultants.
  - Metals in soil are listed for sites that have concentrations greater than Lawrence Berkeley Laboratory (August 1995) background concentrations.
  - PCBs = Polychlorinated Biphenols  
 TPHg = Total Petroleum Hydrocarbons quantified as gasoline  
 TPHd = Total Petroleum Hydrocarbons quantified as diesel  
 VOCs = Volatile Organic Compounds  
 PAHs = Polynuclear Aromatic Hydrocarbons  
 SVOCs = Semi-Volatile Organic Carbons

**SUMMARY OF ANALYTICAL RESULTS**  
**EASTERN PORTION OF BASIN**  
 Yosemite Creek Basin  
 San Francisco, California



Project No.  
4372 AB

Figure 1-3.

Hunters Point Naval Shipyard

	Soil		Groundwater		(Combined A and B-Aquifers)	
	low	high	low	high	low	high
PAHs	up to	1400	PCBs	up to	0.29	
TPHg	up to	9200	Pesticides	up to	0.047	
TPHd	up to	15000	SVOCs	up to	0.16	
TPM-mo	up to	8000	VOCs	up to	0.14	
TEPH	up to	28000	PAHs	up to	0.039	
TPPH	up to	9300	TPHg	up to	2	
TOG	up to	300000	TPHd	up to	12	
PCBs	up to	740	TPM-mo	up to	16	
Pesticides	up to	0.8	TEPH	up to	540	
Dioxins	up to	0.031	TPPH	up to	21	
SVOCs	up to	390	Nitrate as N	up to	8.2	
VOCs	up to	59	Metals			
Metals			Antimony	up to	0.764	
Antimony	up to	1930	Arsenic	up to	1.18	
Arsenic	up to	641	Barium	up to	19.4	
Barium	up to	116800	Beryllium	up to	0.0051	
Beryllium	up to	22	Cadmium	up to	0.0379	
Chromium	up to	330	Total Chromium	up to	2.75	
Cobalt	up to	6940	Copper	up to	0.607	
Copper	up to	1380	Lead	up to	10	
Cyanide	up to	19900	Manganese	up to	9.7	
Lead	up to	11	Molybdenum	up to	4.12	
Mercury	up to	256000	Nickel	up to	6.26	
Molybdenum	up to	76	Selenium	up to	0.016	
Nickel	up to	641	Silver	up to	0.0681	
Nickel	up to	10300	Thallium	up to	0.0175	
Silver	up to	245	Vanadium	up to	0.553	
Vanadium	up to	24900	Zinc	up to	2.4	
Zinc	up to	116000				

Candlestick Point - 49ers Stadium

	Soil		Groundwater	
	low	high	low	high
PCBs	ND	30	Pesticides	ND
Pesticides	ND	0.25	PAHs	0.00012
PAHs	ND	6.9	VOCs	ND
VOCs	ND	0.34	Metals	ND
Metals			Antimony	0.014
Barium	5.1	1200	Barium	ND
Cadmium	ND	5.6	Chromium	ND
Chromium	1.4	660	Cobalt	ND
Cobalt	ND	96	Copper	ND
Copper	2.9	4200	Lead	0.48
Lead	ND	1600	Mercury	ND
Mercury	ND	130	Molybdenum	ND
Nickel	2.4	1300	Nickel	ND
Selenium	1.3	110	Selenium	ND
Vanadium	1.3	110	Silver	ND
Zinc	11	2000	Thallium	ND
			Vanadium	ND
			Zinc	0.15

Buckeye Properties

	Soil		Groundwater	
	low	high	low	high
VOCs	ND	0.9	VOCs	up to
TPH	up to	680	PAHs	ND
Metals	up to	24	SVOCs	up to
Arsenic	up to	12	Metals	up to
Cadmium	up to	440	Antimony	up to
Copper	up to	4	Barium	up to
Cyanide	up to	230	Chromium	up to
Lead	up to	0.7	Copper	up to
Mercury	up to	140	Lead	up to
Nickel	up to	7400	Nickel	up to
Zinc			Vanadium	up to
			Zinc	up to
				14.2

Yosemite Fitch Sewer Construction

	Soil		Groundwater	
	low	high	low	high
TPH	ND	24000	TPH	up to
PAHs	ND	0.5	VOCs	up to
Metals	up to	1400	PAHs	up to
Copper	up to	4.8		2.7
Cyanide	up to	740		
Lead	up to	0.4		
Mercury	up to	1900		
Nickel	up to	7400		
Zinc				

Lucky Lager Brewery

	Soil		Groundwater	
	low	high	low	high
TPHd	up to	34	TPHd	up to
Oil & Grease	up to	560		1.1

7-Up Bottling Company

	Soil		Groundwater	
	low	high	low	high
TPHg	ND	114	TPHg	0.005
TPHd	ND	460	TPHd	0.019
VOCs	ND	3.07	VOCs	ND
Metals			Metals	0.027
Lead	4.6	40	Lead	0.15
				2

Scannell Property/DR Trucking

	Soil		Groundwater	
	low	high	low	high
TPHg	up to	7370	TPHg	up to
VOCs	up to	106	VOCs	up to
Metals			Metals	up to
Lead			Lead	up to
				0.37

Yosemite Creek Basin Boundary Area

Meiten and Gebhardt Tannery

Lucky Lager Brewery

7-Up Bottling Company

Scannell Property/DR Trucking

Buckeye Properties

Yosemite Fitch Sewer Construction

### 1.2.1 Stormwater and Sewer System

Prior to 1958 the Yosemite Creek Basin had three combined sewer and stormwater outfalls, shown in Figure 1-1. These systems were hydraulically isolated and were not connected to the City's main Southeast Treatment Plant. The outfall at the head of Yosemite Creek accounted for the greatest volume of flow from the basin, including the majority of area to the east of Highway 101. Another outfall discharged to the north side of the creek near Griffith Street (Figure 1-1), collecting sanitary and stormwater flows from about 200 acres north of the creek. It included discharges from the Bay Area Drum and Leggett Tannery sites (see Figure 1-3) and also collected sanitary and stormwater discharges from the Hunter's Point Shipyard. A third system collected discharges from the drainage area and industrial facilities located along the southern creek margin. This outfall was located at Fitch Street, near the creek mouth on the southern shore of the South Basin.

In 1959, the Yosemite pump station began operation and all dry-weather flows were thereafter transported and discharged at a depth of 40 feet into San Francisco Bay from the Southeast Treatment Point outfall, located approximately one-half mile north of Hunter's Point. Combined wet-weather flows continued to be discharged from the three CSOs shown in Figure 1-1.

In 1965, the three Yosemite Basin overflow structures were consolidated into a single system located at the mouth of Yosemite Creek. Combined wet-weather overflows occurred an average of 46 times per year. Under provisions of the Clean Water Act of 1972, improved source controls and upgrading of collection and treatment facilities were mandated, leading to substantial reduction in pollutant loadings to the system by the mid-1980s. Several infrastructure improvements were developed, including the placement of large storage and treatment boxes to contain combined flows during wet weather. A storage box for Yosemite Basin flows went into operation in 1990 and an additional box for the adjacent Sunnydale Basin began operation in 1991. These storage facilities have reduced the former incidence of 46 overflows per year into Yosemite Creek, to an average of one per year.

## 1.3 Historical Data

The Regional Water Quality Control Board (CRWQCB 1998) has identified Yosemite Creek and the adjacent South Basin as "sites of concern", citing the presence of pollutants in sediments, including PCBs, PAHs, DDT, chlordane, dieldrin, endrin, tributyl-tin and metals. Contaminated sediments were identified in the 1980s as part of the Navy's Battleship Missouri Homeporting Analysis (Emcon Associates 1987, ESA 1987), and from subsequent 1990s site characterization for ecological risk assessment (PRC 1996) as part of a remedial investigation and feasibility study (RI/FS) under provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). These analyses pointed to Navy sources of contamination, but also introduced the possibility of other potential regional contaminant sources, including Yosemite Creek.

A review of this information, other studies, and results of BPTCP sampling in Yosemite Creek is summarized below

### 1.3.1 BPTCP Studies

BPTCP analyses of sediment chemistry and toxicity were conducted in December, 1995. Results are presented in Hunt et al. (1998). Sediments were collected from a site approximately one-third the distance from the creek origin to the mouth, near SFPUC sampling Station 2 (Figure 2-1, Section 2). Sediments had an 86% silt-clay fraction and total organic carbon (TOC) level of 2.3%. Amphipod tests (85% survival) showed no significant toxicity in comparison with bay reference envelope standards. Urchin larval development tests indicated significant toxicity. Hydrogen sulfide and un-ionized ammonia levels were not elevated. An average ERM quotient was not calculated. However, Mercury and PCB levels were cited as exceeding ERM guidelines. Chlordane was not analyzed.

### 1.3.2 Navy Studies

Sediment analyses conducted for the U.S. Navy in 1994 and reported by PRC (1996) showed elevated concentrations of mercury, total PCBs, total DDT, and chlordane, as summarized in Table 1-2. Sampling locations are shown in Figure 2-1 (Section 2).

**Table 1-2. Sediment chemicals from Yosemite Creek exceeding ERM guidelines. Sampled by PRC for a U.S. Navy Remedial Investigation.**

	Yosemite Creek Maximum	ERM Guideline
Mercury (mg/Kg)	2.2	0.7*
Total PCBs (µg/Kg)	10,500	180*
Total DDT (µg/Kg)	100	46.1*
Total chlordane	25	6.0**

\*From Long et al. (1995). \*\*From Long and Morgan (1991)

Maximum creek levels of PCBs, DDT and chlordane significantly exceeded concentrations recorded from the South Basin, suggesting a possible creek origin for these contaminants. Creek levels of mercury were also higher, with the exception of approximately equal levels (>2 ppm) that were recorded from one area in the northern arm of South Basin.

A detailed assessment of the present condition of Yosemite Creek sediments was conducted by the SFPUC in November 1998. The approach, sampling design, methodology, analytical results, data interpretation and conclusions are presented in report sections that follow, herein.

**SECTION 2**

**SEDIMENT INVESTIGATION**

## 2.0 SEDIMENT INVESTIGATION

The study design and abbreviated methods of data collection and analysis to support project objectives are described in this section. Detailed descriptions of field and laboratory methods, including methods of quality control are presented in the project Sampling and Analysis Plan (ADL 1998). The study was targeted for mid-Fall in an attempt to sample sediments at the end of the dry season. However, there was a heavy rainfall several days prior to the initiation of sampling, producing a CSO overflow. Sediments will be re-sampled during dry weather conditions to see if similar results are produced under different conditions and time.

### 2.1 Sampling Design

Sediments were sampled to measure the vertical and horizontal distribution of sediment chemical contaminants along the length of the creek and from the nearby southwest shoreline of the Hunter's Point Naval Shipyard. Analyses of select trace metals and organic compounds were accompanied by sediment grain size and total organic carbon at 16 sampling stations. Synoptically collected surface sediments were analyzed for sediment toxicity at five of these stations from Yosemite Creek. Creek stations were aligned along five cross-creek transects consisting of two or three stations each (Figure 2-1), located respectively near the north and south shores and, where applicable, in the center of the creek. This alignment was designed to examine sediment characteristics both along the length of, and across, the creek, including locations near historical and present CSOs. A single former Navy sampling Station (5A) was also sampled, located between Transects 4 and 5.

Transects 1 and 2 were located on either side of the main CSO discharge weir, near the creek origin. Transects 3 through 5 extended out to the creek mouth and adjacent area to the south (Figure 2-1). Sampling station descriptions and position coordinates are presented in Table 2-2. Three stations (Transect 6) were located in shallow water along a 120 m segment of the northwestern South Basin (Figure 2-1).

**Table 2-1. Sediment sampling summary: Chemistry, grain size and TOC (C), and amphipod toxicity (T).**

	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 5A	Transect 6*
<u>North</u>							
Surface	C	C(3)	C, T	C	C, T	C, T	C
0 - 1 ft	C	C			C		
1 - 2 ft	C	C			C		
<u>Center</u>							
Surface				C, T	C(3)		C
0 - 1 ft				C			
1 - 2 ft				C			
<u>South</u>							
Surface	C, T	C, T	C	C	C		C
0 - 1 ft			C				
1 - 2 ft			C				

Replicated samples are indicated in parentheses. \* From north arm of western South Basin

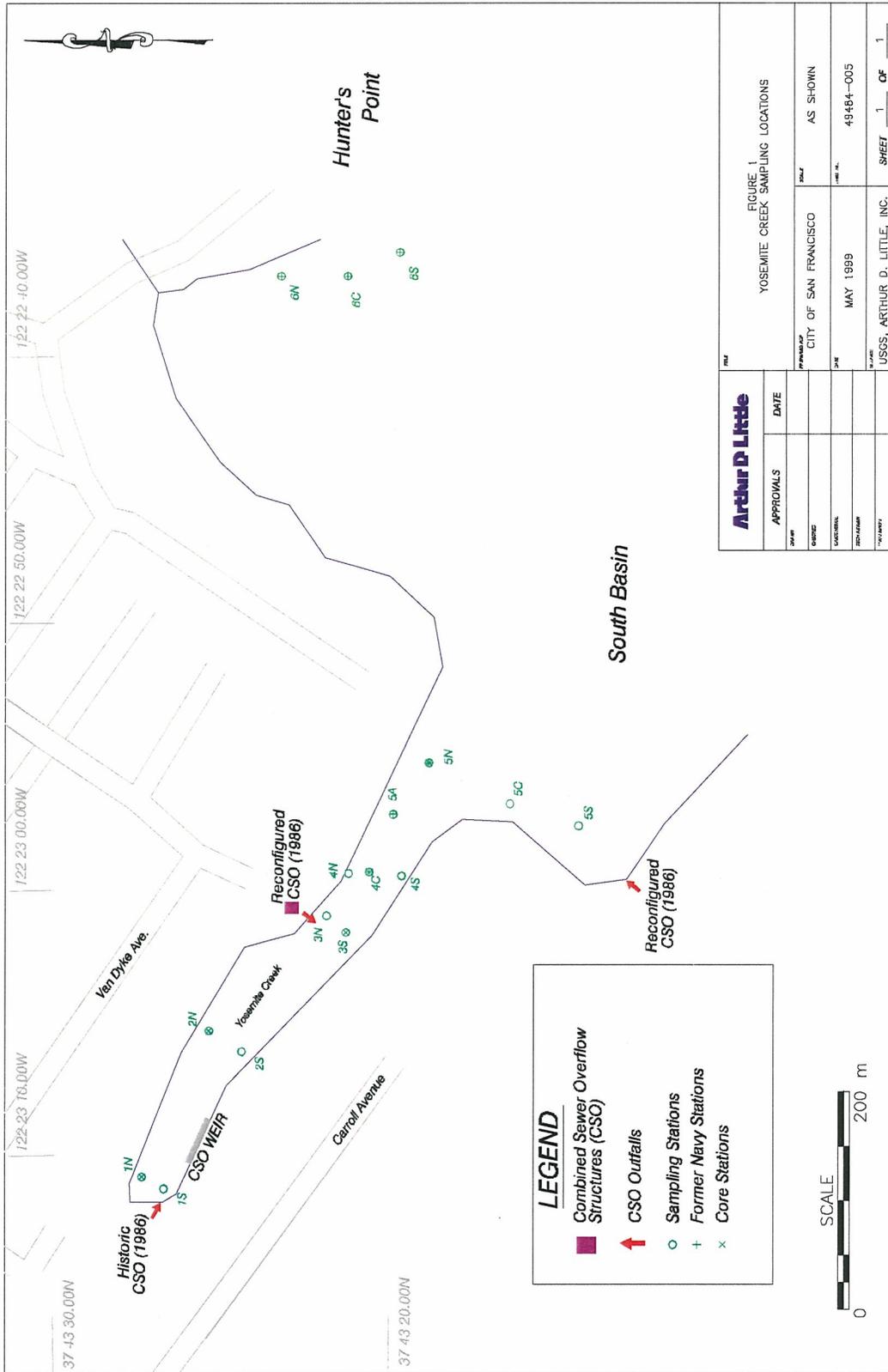


Figure 2-1. Sediment sampling locations at Yosemite Creek and South Basin.

For all 16 stations, sediment was collected from the top 5 cm, homogenized and subsampled for chemistry and grain size. Sediments from a randomly selected station from each of the five transects in Yosemite Creek were sampled for acute toxicity and for subsurface sediment cores. Subsurface cores were collected from the surface to a nominal depth of 4 feet. Sediments were homogenized from 0-1 and 1-2 feet segments and analyzed for chemistry and grain size only. A duplicate core from each station was archived frozen for future analysis (Section 7). Brief descriptions of field, laboratory and analytical methods follow.

**Table 2-2. SFPUC Yosemite Creek sampling locations, November, 1998.**

Station	Date	Depth ft	Latitude (N)	Longitude (W)	Location
<b>Transect 1:</b>					
1N	Nov 2	3	37°43'27.60"	122°23'6.97"	42 m N of S bank, 32 m S of fence on N bank, 90 m W of warehouse
1S	Nov 2	3	37°43'26.95"	122°23'7.42"	34 m W of end structure, 25 m N of grey warehouse, 23 m east of bank
<b>Transect 2:</b>					
2N	Nov 2	3	37°43'25.58"	122°23'1.50"	33 m S of N bank, 44 m N of S bank, 162 m E of warehouse
2S	Nov 2	2.5	37°43'24.60"	122°23'2.30"	62 m S of N bank, 15 m N of S bank, 161 m W of warehouse
<b>Transect 3:</b>					
3N	Nov 4	2	37°43'21.94"	122°22'57.36"	21 m from Griffith St. CSO, 46 m N of S bank, 346 m W of warehouse
3S	Nov 4	<3	37°43'21.73"	122°22'57.61"	Just E of Griffith St. CSO, 21 m from cement block on S bank
<b>Transect 4:</b>					
4N	Nov 4	<3	37°43'21.55"	122°22'55.51"	21 m from N bank
4C	Nov 4	<3	37°43'20.77"	122°22'55.57"	U.S. Navy Target Site
4S	Nov 4	<3	37°43'19.80"	122°22'55.72"	21 m from S bank
<b>Transect 5: Line between cement rubble on N. shore and Fitch Street CSO on S shore</b>					
5N	Nov 4	4	37°43'18.97"	122°22'51.49"	45 m to N bank 216 m to old Fitch Street CSO, U.S. Navy target site
5C	Nov 4	<3	37°43'16.57"	122°22'53.05"	39 m to E shore 130 m to rubble on N shore
5S	Nov 4	<3	37°43'14.53"	122°22'53.89"	197 m from N shore, 70 m from Fitch Street CSO

## 2.2 Field Methods

Field methods are discussed for vessel operation, navigation, sample collection, processing and transport to analytical laboratories. Yosemite Creek surface sediments were sampled on November 2 and 4, 1998 and subsurface cores were collected on December 15, 1998, by scientific staff from the City and County of San Francisco's Water Quality Bureau of Environmental Services.

### 2.2.1 Vessel Operations and Navigation

Field operations were conducted from the vessel, Rincon Point, a 26-ft sampling vessel. The vessel was outfitted with a winch and davit that was used to deploy sediment grab and coring samplers. A Differential Global Positioning System (DGPS) accurate to  $\pm 2$  m was used to position and navigate the vessel during all fieldwork. In addition to DGPS, laser range-finding binoculars accurate to  $\pm 1$  m were used to measure distance from targeted sampling locations and to determine position when the DGPS failed to transmit a signal due to land-based interferences. Positions of sampling stations were recorded in latitude and longitude coordinates (NAD 83) in decimal minutes at the time of sample collection. Distance and bearing were recorded for stations in close proximity to pre-established land-based targets (e.g., CSO, street intersections).

Procedures governing all field sampling operations included establishing assignments, preparing for sampling activities and following the Sampling and Analysis Plan (ADL 1998) directives for recording field data, storing and tracking of samples, and packing and shipping of samples upon completion of field activities.

### 2.2.2 Pre-sampling Preparation

Transit time to and between stations was used to prepare for the next sampling event by setting up field sampling equipment for immediate deployment, decontaminating sampling equipment (e.g., sediment scoops) and preparing sample containers. The following decontamination procedures were used to minimize field contamination:

Chemical sampling equipment was cleaned and decontaminated after use at each station and then set aside on pre-cleaned aluminum foil to prevent possible recontamination.

Polyvinyl gloves were worn during sediment collection and processing; gloves were changed between stations.

Pre-cleaned and certified (i.e., I-CHEM™) jars were used for allocation of sediment chemistry samples.

### 2.2.3 Sediment Sample Collection

Sixteen surface samples and ten sediment cores were collected from a total of 15 stations located within Yosemite Creek and the northwestern segment of South Basin. Additionally, one reference surface sediment sample was collected at Paradise Cove. Surface samples included a total of six field replicates, three each collected at stations 2N and 5C. Sediment cores were collected in duplicate from one randomly selected station at each transect. One core was analyzed and the duplicate core was archived.

Sediment surface samples were collected using a Kynar-coated stainless steel 0.05 m<sup>2</sup> Ponar grab sampler. The top 5 centimeters (cm) of sediment were removed and placed into a Kynar-coated bucket using a Teflon-coated scoop. The scoop was 5 cm deep and was used to gauge the depth of the collected sample. Subsamples were collected from the center of the grab to prevent potential contamination from the grab sampler. Two to three surface samples were collected while the vessel held position until the required volume of four liters were obtained at each station. Each grab was examined to ensure that an undisturbed sample was collected. The combined sediment was then homogenized using a Teflon stir rod and then aliquoted to sample containers. The sample scoop and bucket were cleaned between each station as described in the Sampling and Analysis Plan. Homogenized surface sediment was aliquoted into 500-mL glass, certified clean I-Chem™ jars for organic analyses, 500-mL pre-cleaned polycarbonate containers for analysis of metals, 500-mL glass jars for total organic carbon and grain size analysis, and two 4-L plastic jars for bioassays. Samples were stored on-ice during sampling and subsequent transfer to the SFPUC Oceanside Laboratory.

Subsurface core samples were collected using a 4-inch diameter galvanized steel gravity corer lined with butyrate core liners that were changed with each sample collection. Core samples were collected targeting a depth of 4 ft; however, a nominal core depth of 2-ft was accepted if after several attempts a 4-ft sample was not obtained. Core liners filled with sediment were kept upright and carefully removed from the core barrel. The top of the butyrate liners were cut and removed at the sediment surface, the top and bottom were then covered with Teflon tape and capped with plastic lids, which were then sealed with electrical tape. The top of the core was clearly marked and the sample was kept upright in the dark until subsequent transfer to the laboratory.

#### **2.2.4 Sample Tracking, Storage and Shipping**

All collected samples were placed in appropriate storage containers immediately after collection and affixed with a unique pre-printed label containing the following information: sample identification number, date and time of collection, technician's initials, type of analysis, designated laboratory, and preservative. This information was recorded in the field notebook immediately after collection and subsequently transcribed into an electronic field database. Sediment chemistry samples were transferred to freezers same day of collection at the SFPUC Oceanside Laboratory. Sediment grain size, TOC and bioassay samples were stored in the dark at 4° C until analyzed. A complete sample inventory was generated from field notebooks and checked for completeness. This information was used to generate sample chain-of-custody forms for sample transfer and shipment to off-site laboratories.

Samples designated for analysis at Arthur D. Little's Marine Environmental Laboratory were removed from the freezer and re-packed for next-day air-freight. Shipping coolers included a high coolant to sample ratio to maintain stable sample temperatures during transit. Each shipping container/cooler included a chain-of-custody form, which included sample identifications, collection date, container type and volume of material. Shipper, name of sample custodian, and chain-of-custody numbers were entered into the project database. Sediments designated for toxicity testing at Pacific EcoRisk Laboratory Martinez, California.

## 2.3 Laboratory Methods

The analytical program was designed to provide high quality, detailed chemical and biological data to produce meet program objectives. The analytical approach featured ultra-trace measurements of organic compounds consistent with methods used in the San Francisco Bay Regional Monitoring Program and the Bay Protection and Toxic Cleanup Program. Analyses of conventional (e.g., sediment grain size) and inorganic analytes followed USEPA methods routinely used in other regulatory compliance programs involving sediments, such as dredge material testing programs (e.g., USEPA/USACOE 1991, SW-846). A single 10-day solid-phase toxicity test with the amphipod *Eohaustorius estuarius* was used to characterize sediment toxicity following BPTCP test protocol (modified from ASTM E1367-92).

Analyses were performed for 12 metals, polycyclic aromatic hydrocarbons (PAH), linear alkyl benzenes (LAB), total petroleum hydrocarbons (TPH), chlorinated pesticides, polychlorinated biphenyls (Aroclor and congener forms), and Table 2-3 lists the analytical method and corresponding laboratory for each test. Not all analytes were considered contaminants of concern for creek sediments. Many analytes, such as aluminum, iron, and linear alkyl benzenes were analyzed to support source identification of contaminants of concern. Contaminants of concern and corresponding source identification analytes are identified in the following subsections.

**Table 2-3. Test parameters, performing laboratory and method reference.**

Test Parameter	Method Reference	Method Description
	<i>Arthur D. Little Marine Environmental Laboratory, Cambridge, MA</i>	
Polycyclic aromatic hydrocarbons	EPA 8270 - modified	GC/MS in selected ion mode
Saturated hydrocarbons	EPA 8015 - modified	GC/FID
Linear alkyl benzenes	EPA 8270 - modified	GC/MS in selected ion mode
PCB Congeners	EPA 8081 - modified	GC/ECD dual column
Chlorinated pesticides & Aroclors	EPA 8081	GC/ECD dual column
	<i>SFPUC - Chemistry Laboratory</i>	
Metals	EPA 6010 and 7000 series	ICP/AAGF/AAF
	<i>SFPUC - Oceanside Biology Laboratory</i>	
Grain size	Plumb 1981	Sieve and pipette
Total organic carbon	EPA 9060	Combustion with infra-red detector
Bioassay	BPTCP	10-day solid phase, <i>Eohaustorius</i> sp.
	<i>Pacific EcoRisk Toxicity Laboratory</i>	
Bioassay	BPTCP	10-day solid phase, <i>Eohaustorius</i> sp.

ICP=inductively coupled plasma spectroscopy  
 AAF = atomic absorption with flame detector  
 GC/FID = gas chromatography with flame ionization

AAGF = atomic absorption with graphite furnace detector  
 GC/MS = gas chromatography with mass detector  
 GC/ECD = gas chromatography with electron capture detector

### 2.3.1 Grain size and total organic carbon (TOC)

Grain size and total organic carbon content were analyzed by SFPUC at their Oceanside Biological Laboratory and Chemistry Laboratory, respectively. Grain size was analyzed following a sieve and pipette method described in Plumb (1981). Results were reported for 12 Phi sizes, as well as for four size categories: gravel, sand, silt, clay and the sum of silt and clay (i.e., < 63 µm). Total organic carbon content was measured with combustion followed by infrared spectrophotometry with a non-dispersive infrared detector (ASTM D2574 modified for sediments).

### 2.3.2 Metals

Metals were analyzed using either flame or graphite furnace atomic absorption spectrophotometry, or inductively coupled plasma spectrometry after digestion with nitric acid-hydrochloric acid (Table 2-4). Detection limits ranged from 0.005 to 1.0 milligrams per kilogram ( $\mu\text{g}\cdot\text{g}^{-1}$ , ppm) dry sediment for mercury and lead, respectively.

Although industrialization and development in the coastal zone can result in elevated concentrations of heavy metals, nearly all metals occur naturally in estuarine sediments. Therefore, determination of anthropogenic contribution of a given metal requires establishing the natural metal concentration for a particular sediment. Natural sources of metals to San Francisco Bay sediments are fine-grained clay particles and aluminosilicate minerals. These high-metal content sediments are naturally mixed with low-metal content quartz sands and carbonate shell material. Relative mixtures of these inputs, as well as inputs from contaminant sources, can be discerned by normalizing metal concentrations to aluminum or iron or another determinant that is not distorted by anthropogenic inputs (Bruland et al. 1974; Trefry and Presley 1976; Trefry et al. 1985). These metals, which occur naturally in high concentrations (i.e., > 40,000  $\mu\text{g}/\text{g}$  for aluminum and > 80,000  $\mu\text{g}/\text{g}$  for iron) were included in the sediment investigation to provide source identification information and are not considered chemicals of concern. Aluminum was found to be the best proxy for the metal-bearing phases of Yosemite Creek sediments due to its strong relationships with percent fine (silt + clay) sediment as discussed in Section 4. It is important to determine relative inputs of metal sources, so that naturally elevated metal concentrations are not misinterpreted.

**Table 2-4. Metal analytes, minimum detection limits, and analytical methods**

Metal	Minimum Detection Limit ( $\text{mg}\cdot\text{g}^{-1}$ dry sediment)	Analytical Method
Silver (Ag)	0.2/0.01	ICP/AAGF
Aluminum (Al)	0.5	ICP
Arsenic (As)	1.0/0.025	ICP/AAH
Cadmium (Cd)	0.1/0.01	ICP/AAGF
Chromium (Cr)	0.2	ICP
Copper (Cu)	0.2	ICP
Iron (Fe)	0.3	ICP
Mercury (Hg)	0.005	CVAA
Nickel (Ni)	0.2	ICP
Lead (Pb)	1.0/0.07	ICP/AAGF
Selenium (Se)	0.025	AAH
Zinc (Zn)	0.1	ICP

ICP= Inductively coupled plasma emission spectroscopy  
AAH = Atomic absorption hydride

AAGF= Atomic absorption with graphite furnace  
CVAA = Cold vapor atomic absorption

### 2.3.3 Polycyclic Aromatic Hydrocarbons (PAH) and Linear Alkyl-Benzenes (LAB)

PAHs consist of carbon and hydrogen arranged in two or more fused or linked benzene rings. PAHs tend to concentrate in sediments owing to their relative insolubility in water and high affinity for particulate matter. PAHs are relevant to the ecological health of sediments due to their potential carcinogenic, mutagenic, and toxic effects if bioavailable above threshold concentrations. PAHs are

found in all petroleum-based mixtures including, crude oils, refined fuels, fuel combustion products, preservatives such as creosote and lubricating oils. Natural sources are almost always secondary to anthropogenic inputs and occur from natural oil seeps, forest fires, and direct biogenesis by microbes and plants (Kennish 1992). Potential anthropogenic sources of PAHs to Yosemite Creek are discussed in Section 1.

PAHs were identified as elevated in previous BPTCP studies, thereby contributing to the toxic hot spot listing for Yosemite Creek. The evaluation was based on ERM exceedance for two PAH classes, low and high molecular weight PAHs. However, as discussed in Section 1, the BPTCP evaluation overestimated the corresponding ERM quotients by using additional PAH compounds that were not part of the ERM as defined by Long et al. (1995). For this study, total low and high molecular weight PAH were recalculated using the sum of six and seven PAH compounds, respectively, as prescribed in Long et al. (1995), with subsequent calculation of corresponding ERM quotients for each group. Therefore, only these two classes of PAH were treated as chemicals of concern in this study, with the remaining PAH compounds, consisting primarily of alkylated homologues, used to support source identification of petroleum related contamination.

Sediments were analyzed for an expanded list of PAH that included 20 parent (unalkylated) compounds and 21 alkylated homologues (Table 2-5). The EPA 625/8270 list of PAH compounds (USEPA 1986) was expanded from 16 to 41 to include the alkylated homologues, dibenzothiophenes (sulfur containing compounds), and several additional high molecular weight PAHs. These compounds, particularly the dibenzothiophenes, are often prevalent after weathering, combustion, or biodegradation of petroleum, and can provide insight into the PAH source. The alkylated compounds also persist longer in the environment than their associated parent PAHs, and therefore, provide a more reliable fingerprint, even after extensive environmental degradation (Douglas et al. 1992; Sauer and Boehm 1991; Page et al. 1995). This full-suite of PAH analyses supports one of the project objectives of identifying likely contaminant sources to creek sediments.

Polycyclic aromatic hydrocarbons and linear alkyl benzenes were analyzed using USEPA Method 8270, gas chromatography with mass detector (GC/MS), modified for selective ion monitoring to achieve lower detection limits. Compounds were extracted using a modification of USEPA Method 3050. Sediment samples were extracted three times using sonification followed by 12 hours of shaking using methylene chloride and acetone as the extraction solvent. Additional cleanup procedures were used for sediments including high-pressure liquid chromatography fractionation followed by silica gel and alumina column cleanup. Cleanup procedures were performed to remove potentially interfering non-target compounds. Detection limits for PAH in sediments ranged from 0.07 to 1 micrograms per kilogram dry sediment ( $\mu\text{g}\cdot\text{g}^{-1}$ , ppb) using this method; however, all sediments had concentrations reported above the sample detection limit.

Table 2-5. Polycyclic aromatic hydrocarbons, linear alkyl benzenes and total petroleum hydrocarbons.

Compound	Abbreviation	Compound	Abbreviation
<b>Polycyclic aromatic hydrocarbons (PAH)</b>			
Naphthalene	N	C1-Fluoranthene/Pyrene	FP1
C1-Naphthalenes	N1	C2-Fluoranthene/Pyrene	FP2
C2-Naphthalenes	N2	C3-Fluoranthene/Pyrene	FP3
C3-Naphthalenes	N3	Benzo[a]anthracene	BAA
C4-Naphthalenes	N4	Chrysene	C
Acenaphthylene	AC	C1-Chrysenes	C1
Acenaphthene	ACE	C2-Chrysenes	C2
Biphenyl	B	C3-Chrysenes	C3
Fluorene	F	C4-Chrysenes	C4
C1-Fluorenes	F1	Benzo[b]fluoranthene	BBF
C2-Fluorenes	F2	Benzo[k]fluoranthene	BKF
C3-Fluorenes	F3	Benzo[e]pyrene	BEP
Dibenzothiophene	D	Benzo[a]pyrene	BAP
C1-Dibenzothiophenes	D1	Perylene	PER
C2-Dibenzothiophenes	D2	Indeno[1,2,3-c,d]pyrene	IP
C3-Dibenzothiophenes	D3	Dibenzo[a,h]anthracene	DAA
Phenanthrene	P	Benzo[g,h,i]perylene	BGP
Anthracene	A		
C1-Phenanthrenes/Anthracenes	P1	<b>Linear Alkyl Benzenes (LAB)</b>	
C2-Phenanthrenes/Anthracenes	P2	Phenyl decanes	L10
C3-Phenanthrenes/Anthracenes	P3	Phenyl undecanes	L11
C4-Phenanthrenes/Anthracenes	P4	Phenyl dodecanes	L12
Fluoranthene	FL	Phenyl tridecanes	L13
Pyrene	PY	Phenyl tetradecanes	L14
<b>Total Petroleum Hydrocarbons (TPH)</b>			
<i>n</i> C <sub>9</sub> - <i>n</i> C <sub>40</sub> saturated hydrocarbons	C <sub>9</sub> -C <sub>40</sub>	Isoprenoid 1470	I1470
Pristane	PR	Isoprenoid 1650	I1650
Phytane	PHY	Isoprenoid 1380	I1380

### 2.3.4 Total Petroleum Hydrocarbons (TPH)

Total petroleum hydrocarbons are defined as a group of straight- and branched-chain (saturated) hydrocarbons that are typically found in petroleum related products and crude oil. A complete range of saturated hydrocarbons were analyzed that encompassed light and heavy fractions of petroleum (e.g., *n*C<sub>9</sub>-*n*C<sub>40</sub>); additionally five isoprenoids (e.g., pristane, phytane), which are weather resistant ringed hydrocarbons were analyzed. These hydrocarbons were used solely to support source identification of petroleum-related contamination and were not considered chemicals of concern in this study. Target

analytes (see Table 2-5) were extracted with PAH compounds and analyzed using gas chromatography with flame ionization detection (GC/FID), using a method modified from USEPA 8015. Measured concentrations were calculated against the surrogate compound (tetracosane-d50) added prior to the extraction. Detection limits ranged from 0.1 to 1.0  $\mu\text{g}\cdot\text{g}^{-1}$  dry sediment using this method for individual and total hydrocarbons, respectively.

### 2.3.5 Chlorinated pesticides and polychlorinated biphenyls

Chlorinated pesticides and polychlorinated biphenyls (PCB) were analyzed using dual column gas chromatography with electron capture detector (GC/ECD) (a modification of USEPA Method 8081). Twenty-one USEPA priority pollutant pesticides and 20 PCB congeners were analyzed at less than 1.0  $\text{ng}\cdot\text{g}^{-1}$  dry weight detection limits. Seven USEPA priority pollutant PCB Aroclors were analyzed at 5 to 10  $\text{ng}\cdot\text{g}^{-1}$  detection limits. A complete list of all compounds is shown Table 2-6.

**Table 2-6. PCB Congeners, Aroclors, and Synthetic Pesticides**

PCB Congeners* Detection Limits 0.01-1 ng/g	PCB Aroclors Detection Limits 5-10 ng/g	Synthetic Biocides
		<b>Chlorinated Pesticides</b>
		Detection Limits 0.1-2 ng/g
8 - 2,4'-Dichlorobiphenyl	Aroclor 1016	cis-Nonachlor
18 - 2,2',5'-Trichlorobiphenyl	Aroclor 1221	trans-Nonachlor
28 - 2,4,4'-Trichlorobiphenyl	Aroclor 1232	alpha-Chlordane
44 - 2,2',3,5'-Tetrachlorobiphenyl	Aroclor 1242	gamma-Chlordane
52 - 2,2',5,5'-Tetrachlorobiphenyl	Aroclor 1248	Lindane
66 - 2,3',4,4'-Tetrachlorobiphenyl	Aroclor 1254	Heptachlor
77 - 3,3',4,4'-Tetrachlorobiphenyl	Aroclor 1260	Endrin
101 - 2,2',4,5,5'-Pentachlorobiphenyl		Aldrin
105 - 2,3,3',4,4'-Pentachlorobiphenyl		Heptachlor Epoxide
118 - 2,3',4,4',5'-Pentachlorobiphenyl		Dieldrin
126 - 3,3',4,4',5'-Pentachlorobiphenyl		Mirex
128 - 2,2',3,3',4,4'-Hexachlorobiphenyl		o,p'-DDD
138 - 2,2',3,4,4',5'-Hexachlorobiphenyl		p,p'-DDD
153 - 2,2',4,4',5,5'-Hexachlorobiphenyl		o,p'-DDE
170 - 2,2',3,3',4,4',5'-Heptachlorobiphenyl		p,p'-DDE
180 - 2,2',3,4,4',5,5'-Heptachlorobiphenyl		o,p'-DDT
187 - 2,2',3,4',5,5',6'-Heptachlorobiphenyl		p,p'-DDT
195 - 2,2',3,3',4,4',5,6'-Octachlorobiphenyl		alpha-HCH
206 - 2,2',3,3',4,4',5,5',6'-Nonachlorobiphenyl		beta-HCH
209 - 2,2',3,3',4,4',5,5',6,6'-Decachlorobiphenyl		delta-HCH
		<b>Organophosphorous pesticides</b>
		Detection Limit 400 ng/g
		Chlorpyrifos

\*Congener number is shown before chemical name (i.e., PCB 8 is shown as 8 - 2,4'-Dichlorobiphenyl)

Chlorinated pesticides are synthetic organic compounds that do not occur naturally in the marine environment. However, due to historic waste disposal practices throughout San Francisco Bay, natural dispersion, and their persistence in the marine environment, concentrations of chlorinated pesticides exceed analytical detection limits in most bay sediments (Hunt et al. 1998a; SFEI 1997).

Even though most of these compounds are no longer manufactured, they persist in the environment due to their high stability and affinity for fine-grained particles and organic matter.

PCBs also are a synthetic group of chlorinated hydrocarbons and have been linked to a number of health concerns, such as cancer in man and fin-erosion and lesions in fish (Kennish 1992). They were widely used in manufacturing of adhesives, caulking compounds, as additives to hydraulic fluids, paints, plastics, and most commonly as insulators in electrical transformers and capacitors. These chemicals primarily were manufactured as Aroclors®, which are mixtures of various PCB congeners. Even though PCBs persist in the environment, relative concentrations of individual congeners change as the mixture degrades, making it difficult to detect Aroclors at low levels, using standard analytical methods (i.e., USEPA method 8080). For this reason, PCBs were analyzed as 20 individual congeners, including 18 analyzed in the National Status and Trends Program (NOAA 1995). These congeners have varying degrees of chlorination of the biphenyl molecule. Mono- through deca-chlorinated biphenyl isomers were analyzed, covering broad range of environmentally significant congeners (NOAA 1995). Aroclors were analyzed to compare sediment results to previous land-based Aroclor data and to provide insight into land-based PCB sources.

### 2.3.6 10-day Solid Phase Amphipod Bioassay

The amphipod *Eohaustorius estuarius* was used in a 10-day acute, solid-phase test to characterize sediment toxicity following a BPTCP test protocol (modified from ASTM E1367-92). *Eohaustorius estuarius* typically inhabit well-sorted, fine sediments, generally perform well in a wide variety of sediment types and tolerate a wide range in salinity. Toxicity (i.e., mortality), reported as percent survival, was the only effect measured.

Amphipods were collected in Puget Sound by Brenina & Associates, Inc. Amphipods were received at SFPUC Oceanside Laboratory, in control sediment with overlying seawater. Temperature, dissolved oxygen, pH, and salinity of water overlying the sediment were measured upon organism arrival and daily during acclimation. Tests were started within one week after receipt of test animals.

Toxicity was conducted on duplicate sediments (homogenized splits) by SFPUC and Pacific EcoRisk laboratories using test animals collected from the same population. Test sediments were run with control sediments (collected with the animals) and San Francisco Bay reference sediments collected from Paradise Cove. Prior to the introduction of test organisms, porewater levels of ammonia and sulfides were measured to test for possible confounding toxicants in the test. Overlying water was exchanged for any samples with ammonia levels greater than 20 mg/L using procedures described in the Sampling and Analysis Plan (ADL 1998). At the conclusion of the bioassay, percent survival was reported for each of five laboratory replicates. Passing criterion was  $\geq 90\%$  average control survival and  $\geq 80\%$  in each control replicate on day 10. Average results for station were statistically compared using a standard t-test between laboratories. Results that were not statistically different (i.e.,  $p < 0.05$ ) were averaged across laboratories (using a total of 10 replicates) for each station and reported as mean percent survival. Average results and results for each laboratory are shown in Appendix A.

## 2.4 Sample Archival

After analysis, remaining sediments were archived for future possible chemical analyses for at least one year after date of collection. Replicate surface and core sediments from each station sampled are stored frozen at the SFPUC Chemistry Laboratory. Intact duplicate subsurface cores and the remaining 2-4 feet from the analyzed cores are archived for future analyses (see Section 7).

## 2.5 Data Management and Analysis

All data management and analysis tasks were performed using the SAS<sup>®</sup> Software System (version 6.12) in batch programming mode. SAS<sup>®</sup> is a data management, statistical, and graphical system that is widely used as the recognized standard by many academic, government and medical/health industries worldwide.

Data were translated from Microsoft<sup>®</sup> Excel files to SAS<sup>®</sup> data sets, and all analyses were performed within the SAS<sup>®</sup> system. Statistical results were output as text files and converted back into Excel (for presentation) and presented in Appendix A and Appendix C.

Statistical analyses primarily were performed on a subset of the original data. The subset was selected for key variables (e.g., toxicity) and contaminants of concern. For example, total low and high molecular weight PAH and total PCB were used in computations and summary statistics in place of individual hydrocarbon compounds to reduce the size of the original data set without loss of important information. However, all original PAH and PCB variables were retained for analyses such as principal component analysis (PCA), which was used to identify the type and potential source of hydrocarbons and PCB present in sediments. Brief descriptions of statistical analyses performed follow.

### 2.5.1 Data Transformations

Data were transformed and/or normalized prior to analysis to meet certain test assumptions or adjust results potentially affected by physical characteristics such as grain size. These data modifications are performed routinely in environmental investigations using chemical and biological data, and are used to increase accuracy and aid interpretation of data. Prior to PCA analysis, data were block normalized then log normalized to reduce bias from disparate concentrations in the data set.

### 2.5.2 Descriptive Statistics

Descriptive statistics were performed for physical, chemical, and toxicity data. Results are shown in Appendix C. These statistics included computations for number of samples, sample mean, mean standard deviation, and range of values. Values equal to one-half of the minimum detection limit were used for non-detect chemistry results in mean statistics (e.g., standard deviation). Computations were performed on final results that passed data quality objectives.

### 2.5.3 Correlation Analysis

Correlation analysis provides insight into the relationship between two analysis variables. Both the non-parametric Spearman Rank correlation coefficients and the parametric Pearson Product-Moment

correlation coefficients were calculated for all pair-wise variables within the data set. The correlation coefficients and corresponding significance levels are listed in appropriate sections.

#### **2.5.4 Regression Analysis**

Linear regression analysis was used to search for gradients in contaminant concentrations and toxicity results with distance from the major CSO weir and Quint Street outfall (going towards the bay). Regression analysis of distance with key dependent variables was performed for each of the following transformations: none, square root, square, and log, as previously described. The regression was performed across transect groups (i.e., for all data combined). Additionally, regression analyses were performed between other independent and key dependent variables, such as total organic carbon versus total hydrocarbons, that were significantly correlated. Graphical displays were produced to aid in the interpretation of interactions between key variables.

**SECTION 3**

**GRAIN SIZE AND TOTAL  
ORGANIC CARBON**

### 3.0 GRAIN SIZE AND TOTAL ORGANIC CARBON

Grain size and total organic carbon (TOC) results for surface and subsurface sediments are presented in this section. Grain size characteristics and concentrations of organic carbon (TOC) and acid-volatile sulfide (AVS) are known to have a significant influence on sediment contaminant concentrations and associated toxicity (Di Toro 1990, 1991, Lamberson et al. 1992). Sediment contaminants are frequently associated with low-energy (depositional) environments (such as Yosemite Creek) where fine particles and organic matter accumulate. These environments are potential repositories for contaminants, irrespective of proximity to contaminant source. Despite these facts, widely adopted sediment quality guidelines based upon nationwide studies of sediment toxicity in estuarine and marine sediments (Long et al. 1995), either ignore TOC factors or normalize contaminant concentrations assuming 1% TOC (based on an average concentration of 1.2% TOC for the data used). These guidelines should be interpreted with caution in shallow sedimentary environments of San Francisco Bay where TOC levels frequently exceed 2% or more.

Since the main route of toxic exposure for many organisms occurs from high contaminant bioavailability in sediment pore-water (USEPA 1993), the equilibrium partitioning between the soluble porewater-phase and relatively unavailable phases associated with organic carbon, is a critical factor. For nonionic organic compounds (e.g., chlorinated pesticides, PAH, PCB) that have strong binding affinity for organic carbon, higher TOC levels portend a reduced level of bioavailability. This equilibrium partitioning approach was adopted by the EPA (1993) in the recommendation to normalize nonionic organic chemical sediment concentrations to organic carbon content. Application of these guidelines to three of the five USEPA proposed compounds (i.e., three PAH) would increase sediment quality criteria 2-14 times for sediments with an average TOC concentration of 2.5%, such as those regularly encountered in Yosemite Creek. Sediment quality guidelines adopted by the Regional Water Board for San Francisco Bay (Hunt et al. 1998) utilize NOAA guidelines (Long et al. 1995) that report contaminant concentrations on a sediment dry-weight basis. Total DDT was the only San Francisco Bay "chemical" with a sediment quality criterion based on TOC concentration (i.e., 100  $\mu\text{g}$  total DDT per gram organic carbon [ $100 \mu\text{g}\cdot\text{g}^{-1}$  OC]) from Schwartz et al. (1994). Use of this criterion substantially reduces the effective concentration of DDT in sediments with high TOC, such as Yosemite Creek. For example, a sediment dry weight concentration of 100 ppb DDT corresponds to an organic carbon normalized concentration of 10 ppb DDT for a sample containing 1% TOC (a ten-fold reduction in DDT concentration). The same sediment sample containing 2% TOC (similar to those in Yosemite Creek) would produce a twenty-fold reduction in DDT (i.e., 5 ppb DDT).

In summary, for San Francisco bay standards to determine the extent of chemical contamination, it is recommended that the guidelines be consistent with those on which they are based (i.e., Long et al. 1995). In addition, they should be internally consistent as well as consistent with national criteria (e.g., USEPA 1993). Consistency as well as scientific defensibility calls for use of criteria based on organic carbon content for all nonionic organic compounds, such as that used for total DDT, especially if these data are used in support of biological impacts, as they are within the BPTCP. Development of carbon normalized criteria for nonionic chemicals of concern for Yosemite Creek is proposed in Section 7.

Where applicable, the potential effects of grain size and TOC on sediment concentrations and resulting toxicity are discussed in subsequent sections for Toxicity Results (Section 4) and Chemistry Results (Section 5).

Grain size categories are summarized in Table 3-1. Grain size and TOC data from SFPUC sampling of Yosemite Creek in November 1998 are summarized in Table 3-2. Contour plots of surface fine sediments (Silt + clay) and TOC are shown in Figure 3-1. Surface and subsurface TOC levels are presented in Figure 3-2, and regression plots showing TOC-grain relationships are presented in Figure 3-3.

**Table 3-1. Size class for sediment grain size.**

Grain Diameter (mm)	Size Class	Grain Diameter (mm)	Size Class	Grain Diameter (mm)	Size Class
64	Pebble	0.50	Medium sand	0.031	Medium silt
16		0.42		0.0156	Fine silt
		0.35		0.0078	Very fine silt
		0.30			
4	Granule	0.25	Fine sand	0.0039	Clay
3.36		0.210		0.0020	
2.83		0.177		0.00098	
2.38		0.149		0.00049	
2.00	Very coarse sand	0.125	Very fine sand	0.00024	
1.68		0.105		0.00012	
1.41		0.088		0.00006	
1.19		0.074			
1.00	Coarse sand	0.0625	Coarse silt		
0.84		0.053			
0.71		0.044			
0.59		0.037			

Source: Folk 1968

### 3.1 Grain Size

Yosemite Creek sediments were characterized by silt and clay (particles  $<63\mu$ ) fractions of 80% or more, typically exceeding 90%, with the finer clay fraction ( $<4\mu$ ) generally comprising 30% or more of total sediment dry weight (Table 3-2; Figure 3-1). Sediments of this nature have a strong binding capacity for organic compounds. Sediments from the Navy shipyard were slightly coarser, ranging from 42.4% to 74.2% silts and clays. Finer sediments characterized the area to the south of the creek mouth, the south shoreline near Station 4, and the creek terminus (Transect 1).

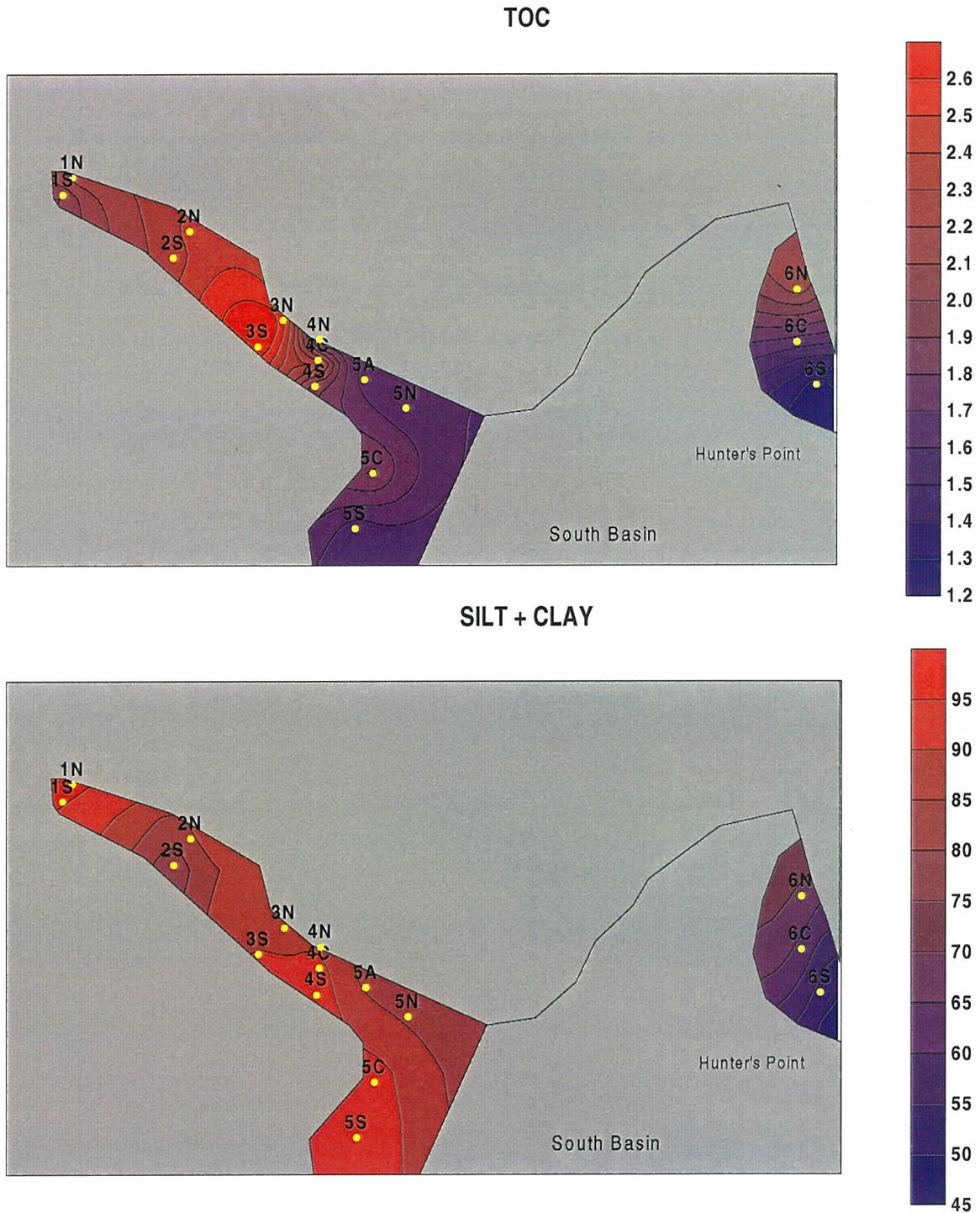


Figure 3-1. Sediment total organic carbon (TOC) and fine sediment (silt+clay), % dry weight.

Table 3-2. Yosemite Creek and South Basin sediment TOC and grain size.

Station	TOC (mg/kg)	Silt	Clay	Silt+Clay
<b>Surface</b>				
1N	22647	87	10	97
1S	19873	59.7	37.8	97.5
2N*	22994	50.6	42.6	93.3
2S	23411	39.8	35.6	75.4
3N	25960	51.6	30.1	81.7
3S	26941	47.2	44	91.2
4C	23854	45.2	46.3	91.5
4N	15557	55.4	36.7	92.1
4S	18948	46.2	43.8	90
5A	16520	34.5	46.7	81.2
5C*	17462	47.1	45.4	92.4
5N	16267	37.2	45.5	82.7
5S	15385	45.7	49.4	95.1
6C	16506	32.2	42	74.2
6N	21519	31.8	39	70.8
6S	12536	18.8	23.6	42.4
<b>Depth 0-1</b>				
1N	39408	79	14.6	93.6
2N	20314	61.2	15.3	76.5
3S	23512	39.5	42.8	82.3
4C	18333	46.9	36.1	83
5N	22454	37	29.2	66.2
<b>Depth 1-2</b>				
1N	13000	9.2	11.2	20.4
2N	16128	25.9	5.7	31.6
3S	25575	35.5	13.4	48.9
4C	17050	29.8	7.2	37
5N	19526	45	43.1	88.1

\* data average for three replicates

### 3.2 Total Organic Carbon

TOC levels up to 2.7% of sediment dry weight were recorded from creek surface sediments, which averaged 2.04% from all stations (Table 3-1; Figure 3-1). TOC levels were elevated in the mid-creek area (Transect 2), diminishing significantly toward the mouth (Transects 4 and 5), and to a lesser degree toward the creek origin. South Basin surface sediments from Transect 6 were variable with generally lower TOC levels than creek sediments (ranging from 1.25% to 2.15% and averaging 1.69%).

Subsurface sediments from the 0-1 ft composite approached 4% at the creek terminus, significantly exceeding levels recorded elsewhere along the creek (Figure 3-2). This may represent a past accumulation from the major CSO prior to improved design and reduction in overflows. However, the deeper (1-2 ft) sediments at Station 1N were the lowest amongst the creek stations. Interpretation of subsurface data in relation to surface data is confounded by the fact that they were sampled approximately six weeks apart (Nov. 2-4 vs. Dec 15). Other areas extending out to Transect 5 showed

indicated reduced TOC in subsurface sediments. Transect 5 subsurface levels exceeded surface values. TOC stratification patterns within the creek are summarized below (Table 3-3).

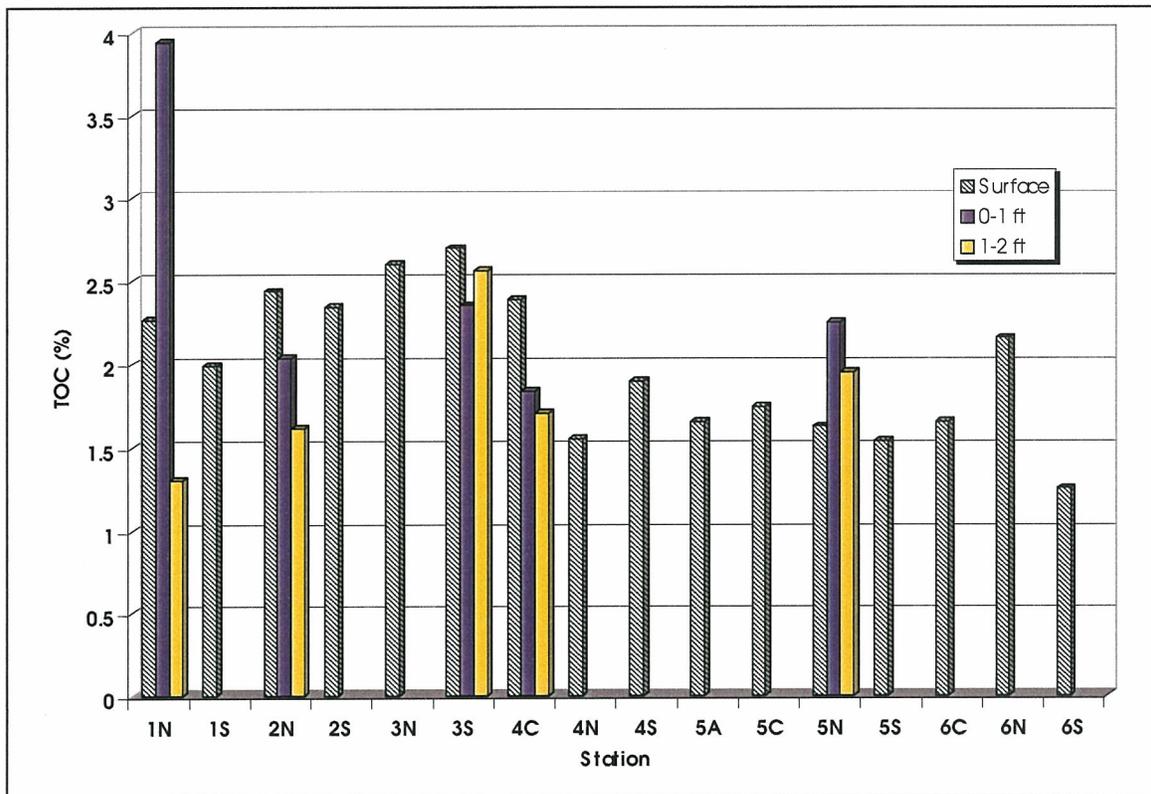


Figure 3-2. TOC concentrations in Yosemite Creek sediments (% dry weight).

Table 3-3. Mean and concentration range of TOC (% dry-weight) by depth in Yosemite Creek

Depth	Mean	Minimum	Station (Minimum)	Maximum	Station (Maximum)
Surface	2.04	1.54	5S	2.69	3S
0 - 1	2.47	1.83	4C	3.94	1N
1 - 2	1.83	1.30	1N	2.55	3S

TOC concentrations in Yosemite Creek are characteristic of fine-grained depositional environments where organic loading of sediments can occur. Average TOC concentrations averaged more than 2% from the top foot of sediments. These conditions present a relatively high capacity for binding and concentrating organic chemical compounds.

TOC concentrations exhibited an unusual relationship to grain size parameters, as summarized in the correlation matrix shown in Table 3-4 and shown in Figure 3-3. TOC was positively correlated with increasing silt clay content (Figure 3-3), but a similar relationship to clay content was not evident. Normally, higher TOC levels are positively associated with finer sediments in estuarine environments, especially with the clay fraction.

Table 3-4. Correlation coefficients (r) for TOC and grain size parameters.

	Silt	Clay	% Fines (Silt + Clay)
TOC	0.474	-0.205	0.389
Silt		-0.541	0.731
Clay			0.178

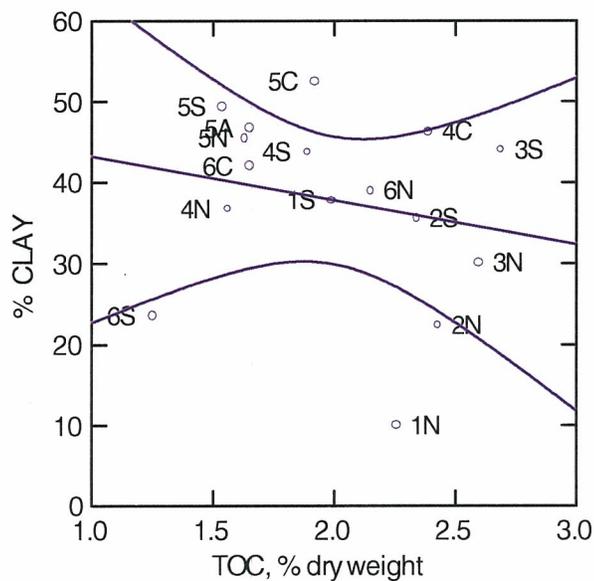
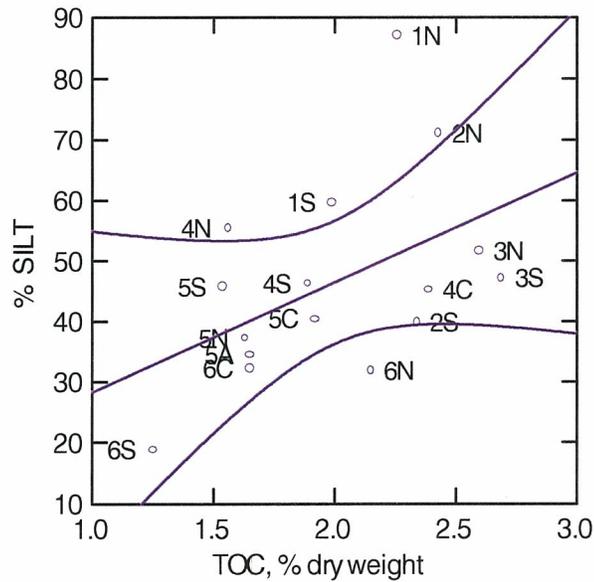


Figure 3-3. Yosemite Creek. Regression of Sediment Silt and Clay Content versus Total Organic Carbon (TOC) with 95% confidence limits.

**SECTION 4**

**TOXICITY**

## 4.0 TOXICITY

This section describes the nature and extent of toxicity to the amphipod *Eohaustorius estuarius* exposed to surface sediments collected at five stations within Yosemite Creek. Mean toxicity results for each station are presented in Appendix A; complete results (including laboratory replicates and water quality data) are included in Appendix C.

Negative control sediment (sediment in which *Eohaustorius* were collected) results averaged 98.5% survival. The San Francisco Bay reference sediments from Paradise Cove had significantly reduced survival, averaging 65% survival (72% as tested by SFPUC; and 58% as tested by Pacific EcoRisk).

### 4.1 Background and Previous Results

In December, 1995, the BPTCP utilized two sediment toxicity tests to characterize Yosemite Creek sediments, 1) A 10-day amphipod test, following standard ASTM (1993, procedures modified to eliminate dry sieving of sediments) for the amphipod test species, *Eohaustorius estuarius*, 2) A sea urchin (*Strongylocentrotus purpuratus*) larval development test under exposure to sediment porewater. Test protocols are described by Chapman et al. (1995). Results were reported by Hunt et al. (1998).

Sediments did not exhibit a high level of toxicity. Amphipod survival was 85%, exceeding the BPTCP survival criterion. Urchin development in porewater was 82% successful, which is lower than the BPTCP standard of 94.3% of reference sediment survival. Sediments had an 86% silt-clay fraction and total organic carbon (TOC) level of 2.3%. Hydrogen sulfide and un-ionized ammonia levels were not elevated. No subsequent toxicity tests were conducted.

Risk assessment studies (PRC 1996) indicated that much of the area throughout the South Basin and Yosemite Creek mouth area showed significant sediment toxicity. Tests included, 1) whole sediment 10-day amphipod bioassays with *Eohaustorius*, 2) porewater echinoderm larval development tests, and, 3) Microtox® tests examining luminescence in the bacterium (*Photobacterium phosphoreum*). Significant amphipod toxicity was recorded at 31 of 37 sampling Navy stations. Twenty stations indicated significant inhibition of urchin development. Microtox tests, conducted on sediments from 75 locations, showed a significant toxic response at 24 (32%) of the sites. All results and significance tests were related to home sediment controls.

#### 4.1.1 SFPUC Tests

The SFPUC initiated sediment chemistry and bioassay analyses in November 1998 in order to delineate the degree and spatial extent of sediment toxicity in Yosemite Creek. Under recommendation from RWQCB, the 10-day whole sediment amphipod test was implemented. Standard test methods are described in Section 2 (Study Design and Methods)

Sediments were collected on November 2 and 4, 1998 at five sites at one station each of the transects ranging from the head of the creek to the creek mouth (Figure 2-1, Section 2). Average amphipod survival was calculated for each station using replicate data from both participating laboratories (i.e., SFPUC and Pacific EcoRisk). Results were averaged for each station as there were no statistical differences between corresponding replicates for each laboratory ( $p \leq 0.05$ ). The primary objective was to

define spatial patterns of sediment toxicity and to determine changes in sediment toxicity that have may have taken place subsequent to BPTCP testing in 1995. Duplicate tests were simultaneously conducted by the SFPUC Laboratory and a contractor laboratory (Pacific EcoRisk), using identical sources of creek sediments and test animals. Creek sediments were compared with amphipod home source sediments as a control, and with sediments from Paradise Cove, an “uncontaminated” site utilized by the BPTCP as a reference area within the bay.

## 4.2 SFPUC Toxicity Results

A summary of average percent survival from all tests from both laboratories is presented in Table 4-1.

**Table 4-1. Toxicity results for the amphipod crustacean, *Eohaustorius estuarius***

Station	Survival* (%)	Survival Range* (%)
1S	66.5	15 – 100
2S	66.0	5 – 95
3N	69.0	20 – 85
4C	62.0	10 – 90
5N	46.0	0 – 80
Reference (Paradise Cove)	65.0	45 - 80
Home Sediment Control	98.5	95 - 100

\* results are for combined data from SFPUC and Pacific EcoRisk laboratories

Combined laboratory results indicated average survivorship marginally below the applied BPTCP reference envelope standard threshold (69.5% of control = 68.8%) at four of the stations, with average survival exceeding 60%. Station 5N had less than 50% survival. High variability was observed within stations. Replicate test results varied in response by differences of 65% to 90% between high and low survival levels. (Table 4-1). Large, potentially predacious, polychaete worms were observed in many of the replicate test chambers at the conclusion of the 10-day exposure period. These worms may have significantly contributed to the laboratory replicate variability. ASTM (1993) testing protocol permits the dry sieving of sediments prior to testing for the expressed purpose of predator removal, however, pre-sieving of test sediments was not done in order to conform with RWQCB guidance. Given the wide range of variability observed, the indication of sediment toxicity potential from all sites should be evaluated with confirmatory tests utilizing pre-sieved sediments and additional bioassay measures such as bioaccumulation and growth potential.

The amphipod survivorship is higher than expected from the presence of several chemicals at concentrations exceeding ERM guidelines (see Section 5, Chemistry Results). However, ERM guidelines are primarily derived from systems with lower TOC levels. Elevated TOC levels in Yosemite creek sediments appear to ameliorate toxic effects by lowering the bioavailability of potentially harmful contaminants due to elevated TOC concentrations.

### 4.2.1 Relationship of toxicity to sediment TOC and grain size

Contaminant levels in sediments and their bioavailability are known to be influenced by sediment organic carbon levels, which normally are positively correlated with finer grained sediments. A

correlation analysis was performed to determine the significance of relationships between amphipod survival, sediment grain size (%fines) and total organic carbon (TOC). The Pearson correlation coefficients are presented in Table 4-2.

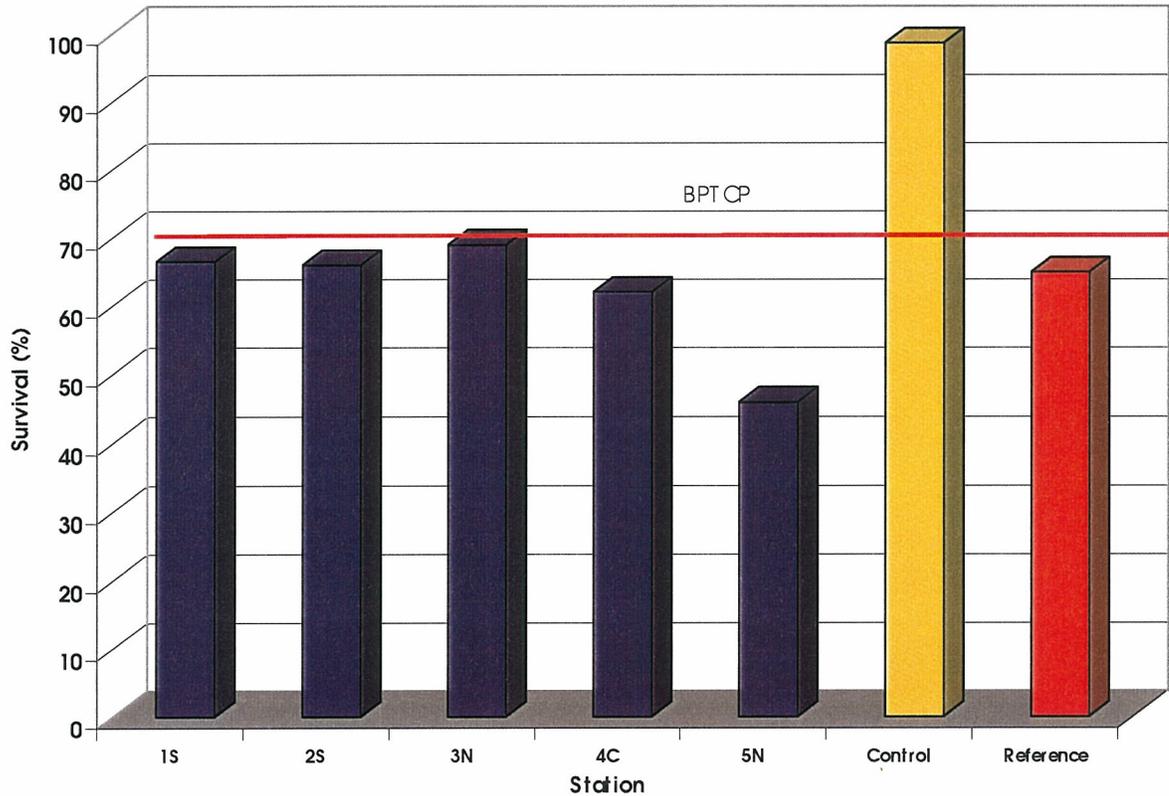


Figure 4-1. Sediment toxicity test results.

Table 4-2. Significant correlation coefficients (r) for Survival, TOC and Fines (Silt + Clay).

	Fines (%)	TOC
Survival (%)	-0.186	0.763
Fines (%)		-0.206

No significant correlations were evident between amphipod survival, fine sediments and TOC.

**SECTION 5**

**CHEMICAL CONTAMINATION**

## 5.0 CHEMICAL CONTAMINATION

Chemical contamination in surface and subsurface sediments is discussed in this section for Yosemite Creek and South Basin (Figure 1-1, Section 1). Where applicable, sediment chemical concentrations are compared to ERM values to assess trends from a broad perspective. For contaminants without corresponding ERMs, concentrations are compared to in-bay reference sediment concentrations (from Paradise Cove) and, in the case of metals, to expected concentrations based on sediment mineralogy. Concentrations exceeding these guidelines are discussed for select groups and individual compounds. Results are organized into contaminant suites, consisting of metals, polycyclic aromatic hydrocarbons (PAH), organochlorine pesticides, and polychlorinated biphenyl (PCB) congeners and Aroclors (Sections 5-1 through 5-4). The distribution of subsurface sediment results is discussed qualitatively, to assess general vertical trends. Yosemite Creek chemicals of concern are identified and discussed in Section 5.5. All chemical concentrations are reported in dry weight. Tabular summaries of chemical data for each station (and field replicate) are presented in Appendix A. Statistical outputs are contained in Appendix C.

### 5.1 Metals

Concentrations of trace metals in Yosemite Creek sediments varied considerably as a function of location, sediment type and TOC concentrations. To help normalize differences in metal concentrations that may result from variations in grain size and mineralogy and to identify sites where metal content may be influenced by anthropogenic inputs, metal concentrations were regressed with iron and aluminum. Aluminum and iron are major constituents of sediment minerals and are usually well correlated with trace metals. Aluminum is mostly present as a structural component of aluminosilicate minerals, whereas iron may occur as a structural component of aluminosilicates as well as an oxide coating on mineral grains. Under natural conditions, when levels of aluminum or iron are higher in a sediment sample, concentrations of trace metals generally also are higher. Lower concentrations of aluminum, iron and metals are found for sediments composed primarily of quartz sand or shell carbonates, whereas higher metal concentrations are common to more clay-rich, fine-grained, organically-rich sediments, such as those encountered in Yosemite Creek. This condition may be encountered even in the absence of contaminant inputs from human activity.

#### 5.1.1 Surface sediments

Plots of metals versus aluminum or iron from a given area with little or no pollutant inputs often show a strong linear relationship. Positive deviations from this linear trend of a metal versus aluminum or iron help identify anthropogenic inputs of that metal to the sediment. As expected, there was a significant correlation between iron and aluminum concentrations for Yosemite Creek surface sediments ( $r^2=0.56$ ,  $p<0.003$ ). However with exception of chromium ( $r^2=0.77$ ,  $p<0.0001$ ), individual metals showed no significant correlation with either aluminum or iron, and scavenging of trace metals by finer aluminum based particles does not appear to be a dominant feature of sediment dynamics in this drainage and depositional system.

Concentrations of trace metals in surface sediments of the creek are summarized in Table 5-1. Mercury was the only trace metal with concentrations that exceeded its ERM guideline value (0.7 ppb). A regression plot of mercury vs. aluminum is presented in Figure 5-1. While a negative correlation is evident, as declining mercury is associated with increased aluminum, the relationship was not statistically significant ( $r^2=0.139$ ,  $p=0.155$ ). Each anomalous data point (above the 95% confidence limits) indicates a potential anthropogenic metal input at the specified station. The positive outlying values in Figure 5-1 distinguish the coarser sediments from the South Basin Transect 6 which had elevated mercury concentrations of 1.14 and 1.03 ppm at Stations 6N and 6C, respectively (Figure 5-1). Sediments within the creek having elevated surface levels of mercury were found at Transect 3 (Figure 2-1, Section 2) (Stations 3S and 3N, 0.94 and 0.73 ppm, respectively), where mercury levels were marginally above the ERM of 0.7 ppm. A concentration equaling the ERM was recorded from Station 1N at the creek origin. Nickel was the only other metal that exceeded the ERM value; however, nickel concentrations typically exceed the ERM of 51.6 ppm in reference areas throughout the bay (Hunt et al. 1998a), and it is therefore, not considered a chemical of concern.

**Table 5-1. Descriptive statistics for surface metal concentrations ( $\mu\text{g}\cdot\text{g}^{-1}$ , ppm dry weight).**

Metal	Minimum	Maximum	Mean	Standard Deviation	ERL*	ERM*
Aluminum	30320.00	50725.00	38875.67	5926.73	na	na
Arsenic	8.20	11.40	9.26	0.79	8.2	70
Cadmium	0.41	1.37	0.73	0.29	1.2	9.6
Chromium	107.00	143.00	123.10	11.34	81	370
Copper	79.00	141.00	102.82	15.57	34	270
Iron	35765.00	47306.00	40358.15	3305.09	na	na
Lead	92.00	168.00	131.31	22.65	467	218
Mercury	0.53	<b>0.94</b>	0.64	0.11	0.15	0.71
Nickel	<b>78.00</b>	98.00	<b>88.38</b>	6.34	20.9	51.6
Selenium	0.28	0.96	0.38	0.18	na	na
Silver	<0.50	0.60	0.42	0.13	1	3.7
Zinc	186.00	289.00	224.49	26.82	150	410

\* source Long et al. (1995), assumes a 1% TOC concentration  
na = not available; bold indicates > ERM

To further explore potential sources of elevated metals levels and to identify potential transport pathways, metals concentrations were correlated with TOC and fine-grained sediments (% fines, i.e., < 63  $\mu\text{m}$  diameter). Mercury, lead and zinc had high positive significant correlations with TOC (Table 5-2). The weak negative correlation between TOC and grain size (% fines) discussed in Section 3 is unusual for sediments, which typically show a strong positive correlation. Several examples that would undermine a positive relationship include sandy sediments that support grasses (e.g., eel grass) or high detrital (e.g., algae) depositional areas (e.g., a creek terminus that is not well flushed). Regardless of the source of the unusual TOC/grain size relationship, elevated metals in Creek typically co-occur with the highest concentrations of TOC measured in these sediments. Copper was the only exception to this generality. The strength of this relationship as evidenced in Table 5-3 confounds the determination of the contaminant source for these metals, which cannot be inferred by proximity to a contaminant source. In particular, lead, mercury (methylated forms) and zinc all readily bioaccumulate in plants in

contrast to arsenic and chromium (Kennish 1992), and these metals showed the most significant positive correlation with TOC (Table 5-2). The fact that lead, mercury and zinc were well-correlated with TOC, indicates their possible source through bioaccumulation in plants (e.g., grasses, algae). Marine plants can bioconcentrate select metals several hundred times over background sediment concentrations. These plants either scavenge metals from the water column or take them up directly from sediments (e.g., grass). In either scenario, when the plant dies it becomes part of the sediment matrix, increasing both the organic carbon and metal concentration of the sediment. Therefore, any sediment that has high organic carbon can have elevated concentrations of select metals, without the presence of a "contaminant source". This is a different mechanism than the adsorption and resulting concentration of metals with fine-grained sediments, which is less discriminating than plant uptake. The contour plot for mercury in creek sediments is shown in Figure 5-2. The positive metal/TOC correlation shown in Table 5-2 ( $r^2=0.80$ ;  $p=.001$ ) was the most significant amongst the metals. Additionally, the only ERM exceedances for mercury were in sediments with correspondingly high concentrations of TOC (i.e., > 2.3%). Notably, most metals were not positively correlated with finer sediments, as is typical in estuarine and marine sediments. Additional analyses, with further separation of sediment size classes may distinguish the details of distribution within the finer sediment categories of silt and clay.

The only other ERM exceedance in surface sediments was for nickel, which is not a chemical of concern due to naturally high background concentrations throughout San Francisco Bay (Hunt et al. 1998a).

Selenium, like mercury, is a trace element of concern due to its high potential for bioaccumulation. Selenium concentrations within the creek ranged from 0.028 to 0.96  $\mu\text{g}\cdot\text{g}^{-1}$ , with an average concentration of 0.38  $\mu\text{g}\cdot\text{g}^{-1}$ . ERM guidelines have not been developed for selenium. Selenium concentrations below 0.33  $\mu\text{g}\cdot\text{g}^{-1}$  are reported as uncontaminated background for San Francisco Bay sediments (Walters and Gartner 1985).

**Table 5-2. Correlation Coefficients (r) and probabilities (p) for metals vs. TOC and %Fines**

	Aluminum	Arsenic	Cadmium	Chromium	Copper	Iron	Mercury	Lead	Nickel	Selenium	Silver	Zinc
TOC (r)	0.021	0.463	0.502	0.369	-0.021	0.138	<b>0.798</b>	<b>0.652</b>	0.188	0.258	0.394	<b>0.655</b>
(p)	0.9450	0.1110	0.0806	0.2147	0.9461	0.6537	0.0011	0.0158	0.5377	0.3938	0.1826	0.0151
%Fines (r)	0.415	0.316	-0.176	0.309	0.618	<b>0.652</b>	0.012	-0.021	<b>0.782</b>	0.338	0.307	0.303
(p)	0.1590	0.2923	0.5660	0.3050	0.0244	0.0158	0.9679	0.9451	0.0016	0.2591	0.3077	0.3136

Bold indicates significant positive correlation ( $p\leq 0.05$ )

### 5.1.2 Subsurface sediments

Subsurface concentrations for all sediment metals presented in Appendix A. Mercury concentrations exhibited complex patterns of vertical profile along the creek bed (Figure 5-3). The upper 1-ft composite at the creek origin showed the highest value (1.49 ppm), followed by surface and deepest (1-2 ft) sediments from Station 3S and the upper 1-ft. from Station 5 N. This is indicative of localized influxes into the creek with differing periodicity. With the exception of the 1-ft. composite from the creek origin, stations closer to the mouth of the creek showed relatively high levels. Surface mercury levels from Transect 6 in the South Basin ranged from 0.81 ppm to 1.14 ppm, averaging 0.99 ppm and exceeding the surface levels from the creek. This indicates that significant sources of mercury may be present in sediments outside the creek.

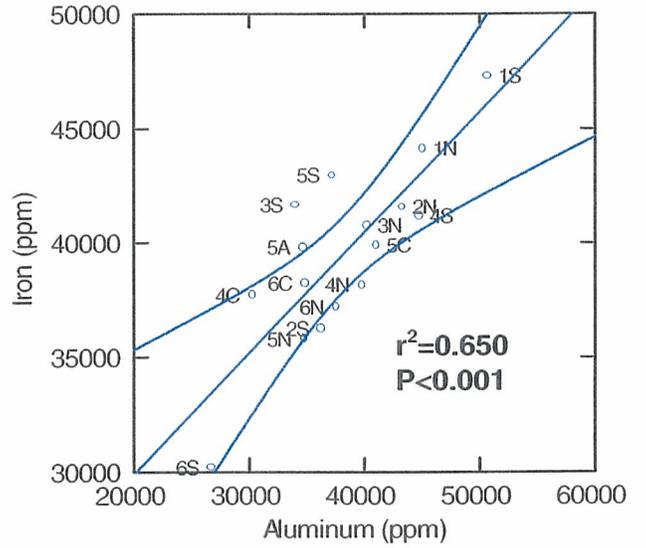
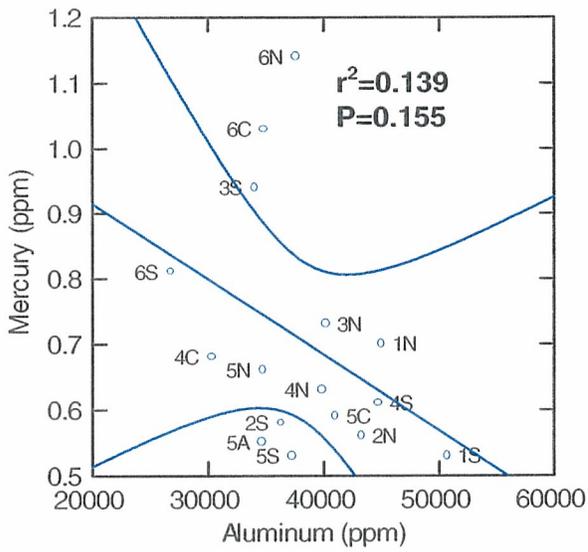


Figure 5-1. Regression of aluminum vs. mercury and aluminum vs. iron in surface sediments with 95% confidence limits.

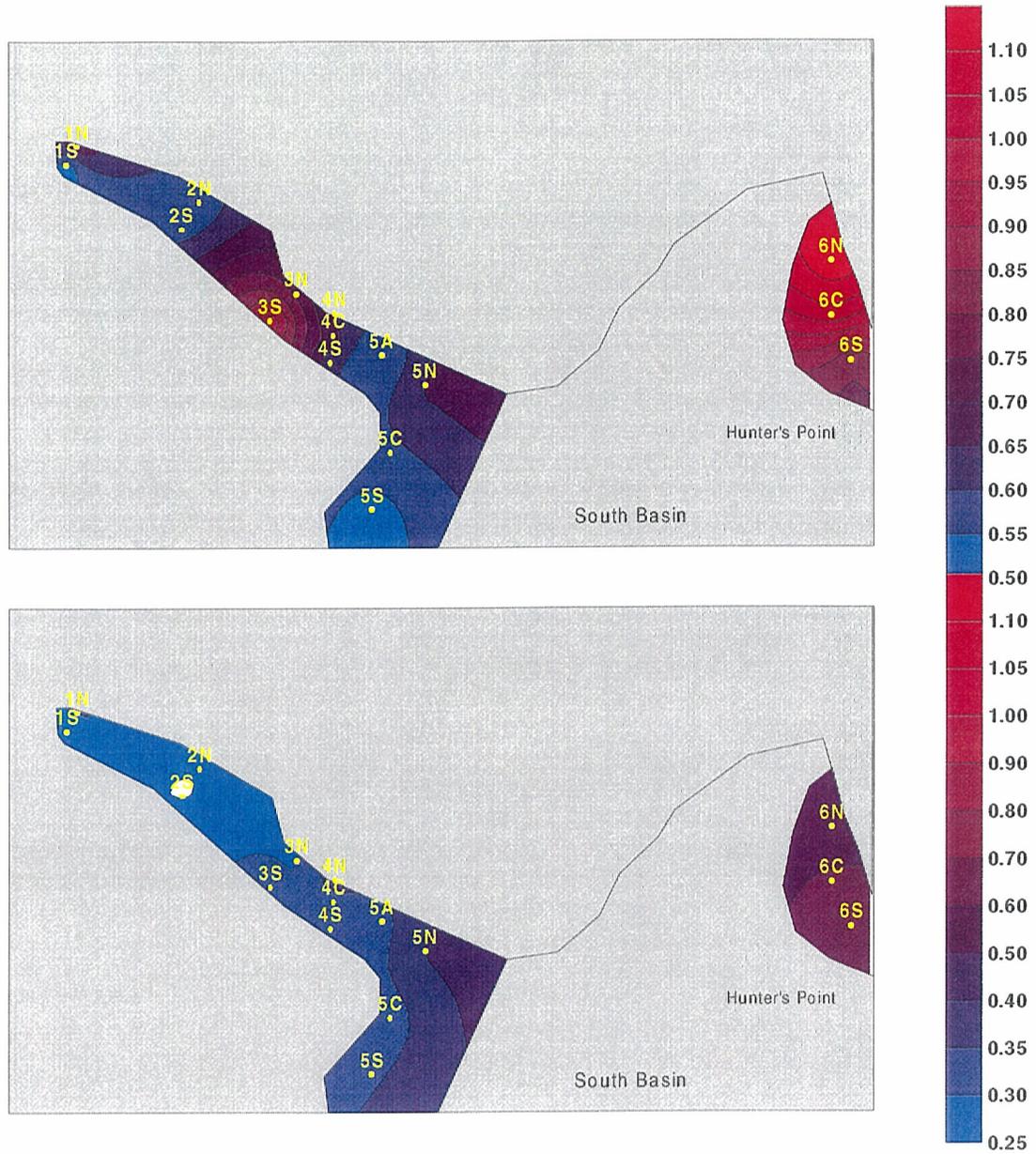


Figure 5-2. Distribution of mercury and TOC-normalized mercury in Yosemite Creek and South Basin surface sediments.

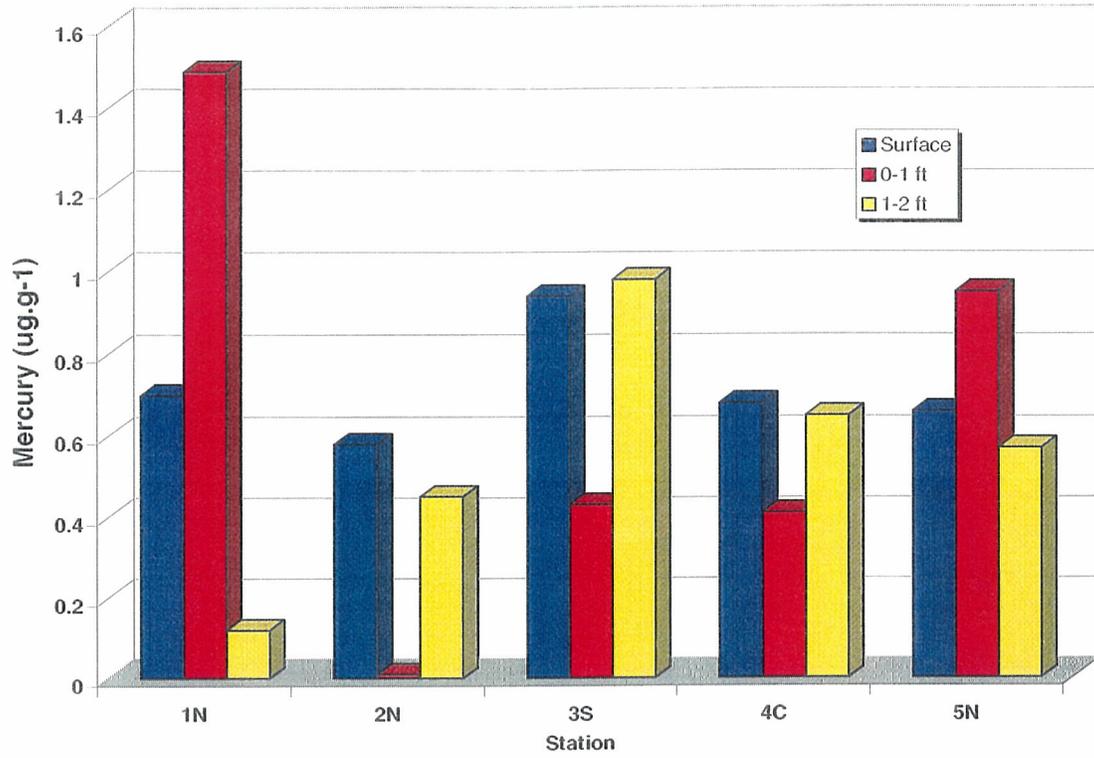


Figure 5-3. Concentrations of mercury for each depth at Yosemite Creek subsurface stations.

### 5.1.3 Source identification of elevated metals

There are numerous contaminant sources for metals to sediments, including sources of lead and zinc from auto emissions (e.g., trace lead from fuel and catalytic converters) and particulate matter from brakes. Historical use of mercury was prevalent in the early century from silver mining, and elevated inputs of mercury to the bay continue from land-based run-off of contaminated soils. More recent sources include use of mercury in fungicides (Kennish 1992). Potential entrance points of these metals to Yosemite Creek include the CSOs, land-based storm runoff along the side of the creek, ground water transport, atmospheric fallout and the bay itself. However, because of the distribution and high relative concentrations of TOC, metal source cannot be directly inferred by proximity to localized contaminant sources. This is especially true for sediments in the mid creek area (Section 3, Figure 3-1), which are high in TOC. Determination of contaminant source requires analysis of potential source materials, including particulate matter from the CSO, and runoff and seepage from source material along the creek.

## 5.2 Polycyclic aromatic hydrocarbons (PAH)

Concentrations of PAH, like metals, in Yosemite Creek sediments varied considerably as a function of location, sediment type and TOC concentration. Concentrations of PAH, which are nonionic organic compounds, also tend to increase with increasing TOC due to their relative insolubility in water and high affinity for particulate matter (Section 2.3.3). This relationship is well documented as evidenced in the EPA's proposed TOC-normalized sediment quality criteria for three PAH compounds (see Section 1.2.4.2).

The sum of low molecular weight (LMW) and high molecular weight (HMW) PAH, as calculated by Long et al. (1995) were used to assess the extent of contamination in Yosemite Creek sediments following BPTCP guidelines. The additional 28 PAH compounds analyzed were used to provide information on the type and potential source of PAH, which primarily enter the environment as petroleum-related contamination (Section 5.2.3).

### 5.2.1 Surface sediment results

Higher relative concentrations of HMW PAH compared to LMW PAH were measured in all surface sediments. This pattern is generally associated with combustion of fossil fuels and/or inputs from coal tars, where higher relative concentrations of LMW PAH typically signify inputs from non-combusted sources (e.g., fuel or crude oil) (Section 5.2.3). Mean sediment concentrations were 601 and 2544 ppb dry weight sediment, respectively, for LMW and HMW PAH (Table 5-3). The ERM value (9,600 ppb) for HMW PAH was not exceeded in surface sediments. A concentration of 16,180 ppb from the upper 1-ft composite at Station 1N was the only recorded level exceeding the ERM guideline. This same core segment from the creek origin also had the only LMW PAH concentration (3380 ppb) that exceeded the ERM guideline of 3160 ppb.

Table 5-3. Descriptive statistics for surface PAH concentrations (ng·g<sup>-1</sup>, ppb dry weight).

Parameter	Minimum	Maximum	Mean	Standard Deviation	ERL*	ERM*
HMW PAH	1228	4740	2544	1188	552	3160
LMW PAH	255	1082	601	260	1700	9600

\* source Long et al. (1995), assumes a 1.2% TOC concentration

## 5.2.2 Subsurface sediment results

## 5.2.3 Source identification of PAH

Source identification of petroleum hydrocarbons was performed using sediment results from the analysis of total petroleum hydrocarbons (TPH) and polycyclic aromatic hydrocarbons (PAH). A total of 37 TPH and 41 PAH compounds were analyzed as described in Section 2, providing information necessary for statistical and qualitative fingerprinting methods. Preliminary results from the source identification of PAH are contained in Appendix D.

## 5.3 Organochlorine Pesticides

Organochlorine pesticides measured in sediments included five categories of compounds: 1) six isomers of DDT (including DDD and DDE degradation products); 2) the Chlordane isomers and congeners, alpha-Chlordane, gamma-Chlordane, cis-Nonachlor, trans-Nonachlor, Heptachlor and Heptachlor epoxide; 3) Aldrin and its metabolites Dieldrin and Endrin; 4) Lindane; and 5) Mirex. Each of these compounds has potentially toxic effects upon marine organisms if sufficiently concentrated and bioavailable. Some compounds, such as DDT, are notable for their biomagnification in fatty tissues, with increasing tissue concentrations at successively higher levels of the food chain. These pesticides also are nonionic organic compounds that have a high affinity for organic carbon (EPA 1993), preferentially concentrating in high TOC sediments. Organochlorine pesticides were omitted from Long et al. (1995) due to low confidence in previously published values, especially for total Chlordane (see Section 1). Therefore, total Chlordane was not evaluated based on the Long and Morgan 1991 ERM guideline as was used in the BPTCP. Dieldrin and Endrin were evaluated using this guideline as discussed in Section 1; however, comparative results for San Francisco Bay sediments should be used only tentatively. Since ERM guidelines do not exist for these compounds, and total Chlordane was chemical of concern in previous BPTCP studies, lower creek sediment concentrations of Chlordane are compared to Paradise Cove and upper creek (i.e., east of transect 4) concentrations taking TOC into account. Applicable sediment quality guidelines for organochlorine pesticides of concern should be determined empirically through spiked sediment toxicity tests, as was done for DDT (Schwartz et al. 1994).

Many of the individual compounds were present at concentrations below the detection limits (usually < 0.5 ppb), including Aldrin, Endrin, Lindane, Mirex, and many of the individual Chlordane and DDT isomers.

Chlordane and Dieldrin were routinely measured and detected at levels exceeding 25 ppb; however, they were significantly correlated with TOC concentration (Figure 5-4). Distributions of these compounds in surface sediments are shown in Figure 5-5. Distribution for total DDT is shown in Figure 5-6. Summary results for surface and subsurface sediments are presented in Table 5-4.

**Table 5-4. Summary statistics for total DDT, total Chlordane and Dieldrin (ppb dry weight).**

Category	Stratum	Mean	Maximum	Maximum Station	Minimum	Minimum Station
Total DDT	Surface	65.22	142.5	2S	18.36	5S
	0' - 1'	378.41	1431	1N	42.42	4C
	1' - 2'	132.32	235.5	3S	50.86	1N
Total Chlordane	Surface	33.81	78.2	1N	10.3	5S
	0' - 1'	72.62	208	1N	22.0	4C
	1' - 2'	40.55	68.8	3S	3.37	1N
Dieldrin	Surface	39.05	110	2S	3.37	5S
	0' - 1'	119.20	370	1N	26.0	2N
	1' - 2'	78.40	120	3S	21.0	1N

### 5.3.1 DDT

Total DDT averaged 65 ppb in Yosemite Creek surface sediments, with a maximum of 147 ppb at Station 2S (Figure 5-6; Table 5-4). South Basin sediments (Transect 6) had lower concentrations, ranging from 37 ppb to 56 ppb (average 42.8 ppb). The major DDT metabolites contributing to total DDT were 4,4-DDD and 4,4-DDE (Appendix A). Subsurface creek sediments had higher DDT concentrations than surface sediments, averaging 378 ppb and 132 ppb from composites of 0-1 and 1-2 ft core segments, respectively. Maximum concentrations from the 1-ft composite were recorded at the end of the creek (Station 1N, 1430 ppb), and from the deeper 1-2 ft segment at Station 3S (235 ppb) (Table 5-4). Comparatively lower total DDT levels in surface sediments indicate a trend of declining DDT in more recent sediment deposits.

All surface sediments had total DDT concentrations below the BPTCP criterion of 100  $\mu\text{g g}^{-1}$ -organic carbon, as TOC concentrations exceeded 2.3% at the single surface station exceeding 100 ppb (1N; 147 ppb). The corresponding BPTCP TOC normalized ERM criterion (adopted from Schwartz et al. [1994]) is 323 ppb for these sediments.

### 5.3.2 Chlordane

Total chlordane concentration averaged 34 ppb in surface sediments (Table 5-4). The highest concentration was measured at Station 1N at 78 ppb, as Chlordane exhibited a diffused pattern of elevation in the western creek channel. Surface Chlordane levels from South Basin Transect 6 were relatively low, averaging 12 ppb (Figure 5-5).

Subsurface concentrations in the creek exceeded surface levels, averaging 41 ppb and 39 ppb from 0-1 ft. and 1-2 ft. core segments, from Stations 1N and 3S respectively. The most prevalent isomers of Chlordane were alpha- and gamma-Chlordane, and trans-Nonachlor. Heptachlor and Heptachlor epoxide were not found above detection limits (ca. 0.5 ppb).

Chlordane, like other non-polar organic compounds, has an affinity for organic matter, as indicated in Figure 5-4 ( $r^2=0.649$ ,  $p=.039$ ). Sediment toxicity ERM guidelines are advisedly normalized to TOC content, since, as discussed in Section 1.2.4, bioavailability of nonionic organic compounds is reduced in sediments with elevated TOC concentrations.

### 5.3.3 Dieldrin

The average concentration of Dieldrin in surface samples was 39 ppb, with a maximum of 110 ppb measured from Station 2S. As evident in Figure 5-5, concentrations are lower in sediments of the eastern creek channel. Surface sediment concentrations from the South Basin were lower than creek levels, ranging from 19-32 ppb (average 26 ppb).

Subsurface core composite concentrations exceeded surface concentrations, averaging 119 and 78 ppb from the upper 1-ft. composite, and 1'-2' segment, respectively. A maximum of 370 ppb was recorded from the upper 1-ft. segment at the creek origin (Station 1N). This exceeded the maxima from the deeper (1-2 ft) segment (120 ppb from Station 3S). Comparatively reduced surface levels are reflective of a declining Dieldrin input from recent sediment deposits. Dieldrin showed the same pattern as DDT and Chlordane in being positively correlated with sediment TOC (Figure 5-4).

## 5.4 Polychlorinated biphenyls (PCB)

The horizontal distribution of total PCB in Yosemite Creek was similar to that for PAH, varying considerably as a function of location, sediment type and TOC concentration. PCB are also nonionic organic compounds, which generally increase with increasing TOC due to their relative insolubility in water and high affinity for organic matter (Section 2.3.3). The sum of 18 NOAA Status and Trends PCB congeners, as calculated by Hunt et al. (1998) were used to assess the extent of contamination in Yosemite Creek sediments following BPTCP guidelines.

### 5.4.1 Surface sediment results

Summary statistics for total PCB for surface (and subsurface) sediments including mean, range, and standard deviation are shown in Table 5-5. Total PCB concentrations ranged from 244 to 804 ppb in surface sediments from the creek, averaging 435 ppb, with the highest concentrations measured in the western creek channel, and with a maximum at Station 2S (Figure 5-6). Significantly higher levels were recorded from the South Basin, where the surface average was approximately double (873 ppb) the average surface concentration from the creek. The maximum South Basin value was measured at Station 6N (1100 ppb). This pattern indicates that outside sources may significantly contribute to observed PCB concentrations within the creek channel.

The distribution of total PCB was not significantly correlated with TOC, taking into account the relatively low TOC levels from South Basin where PCB were elevated (Figure 5-6).

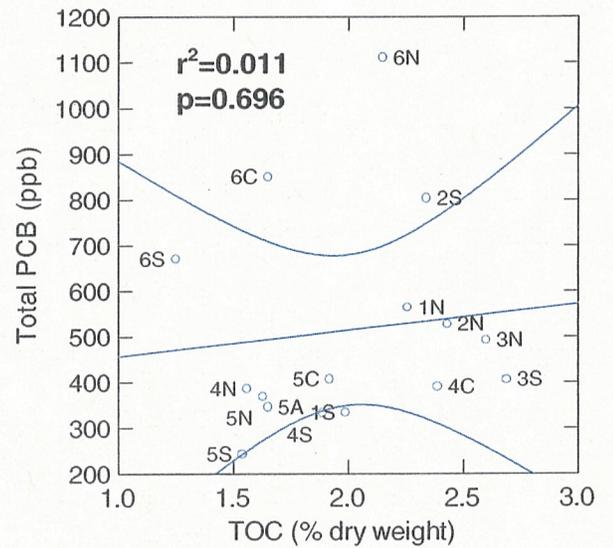
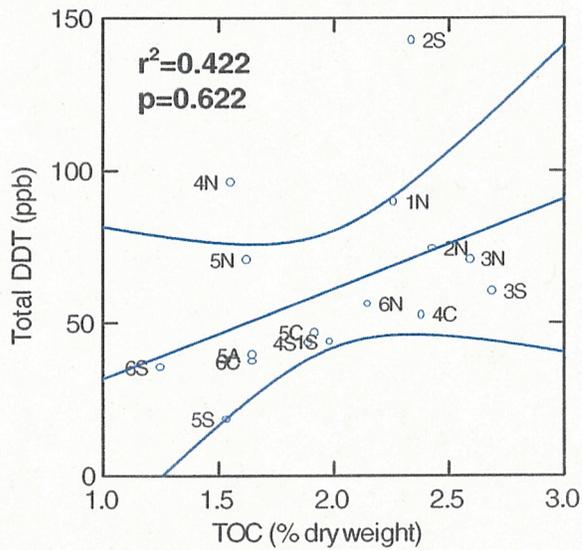
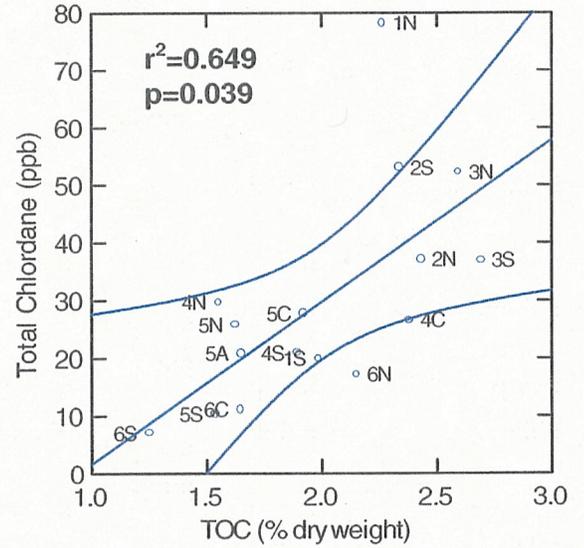
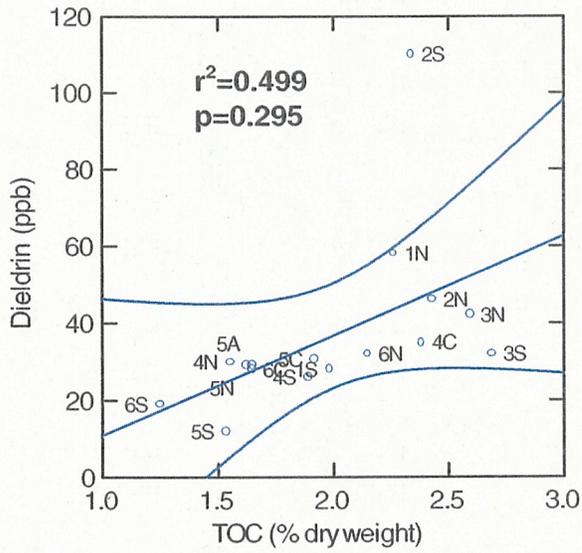
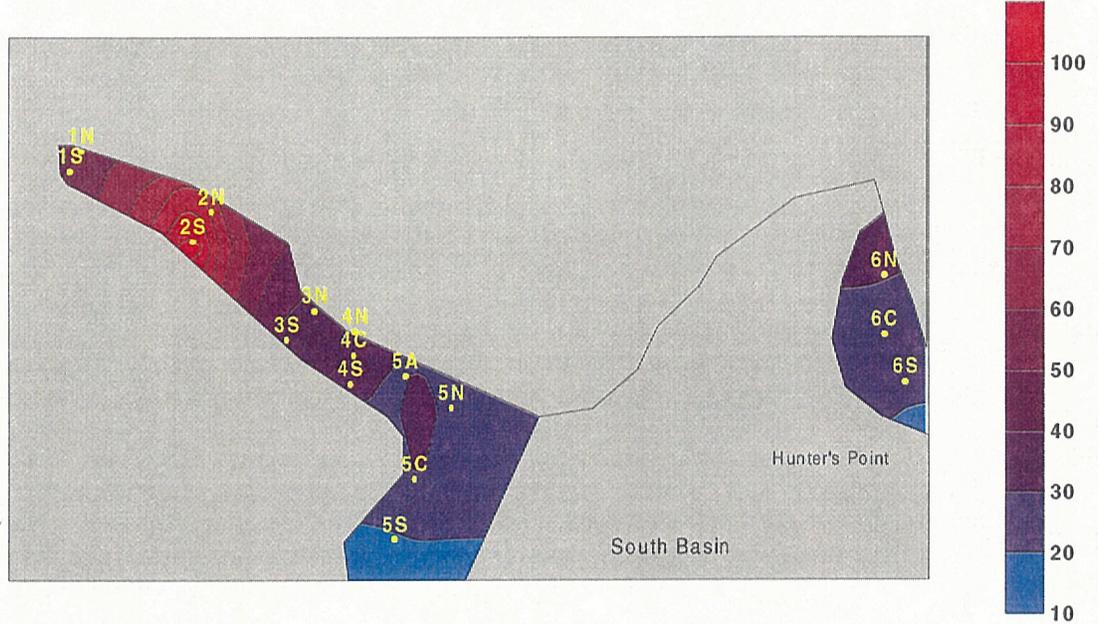


Figure 5-4. Yosemite Creek. Regression of Sediment Dieldrin, Total Chlordane, Total DDT and Total PCB Content versus Total Organic Carbon (TOC) with 95% confidence limits.

Dieldrin (ppb dry weight)



Total Chlordane (ppb dry weight)

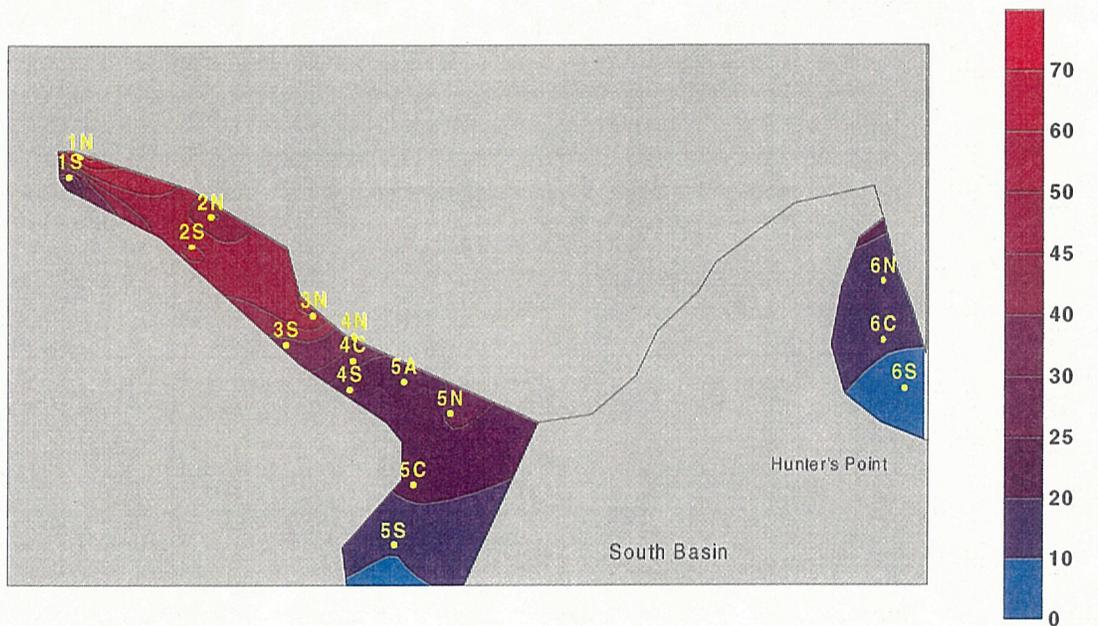
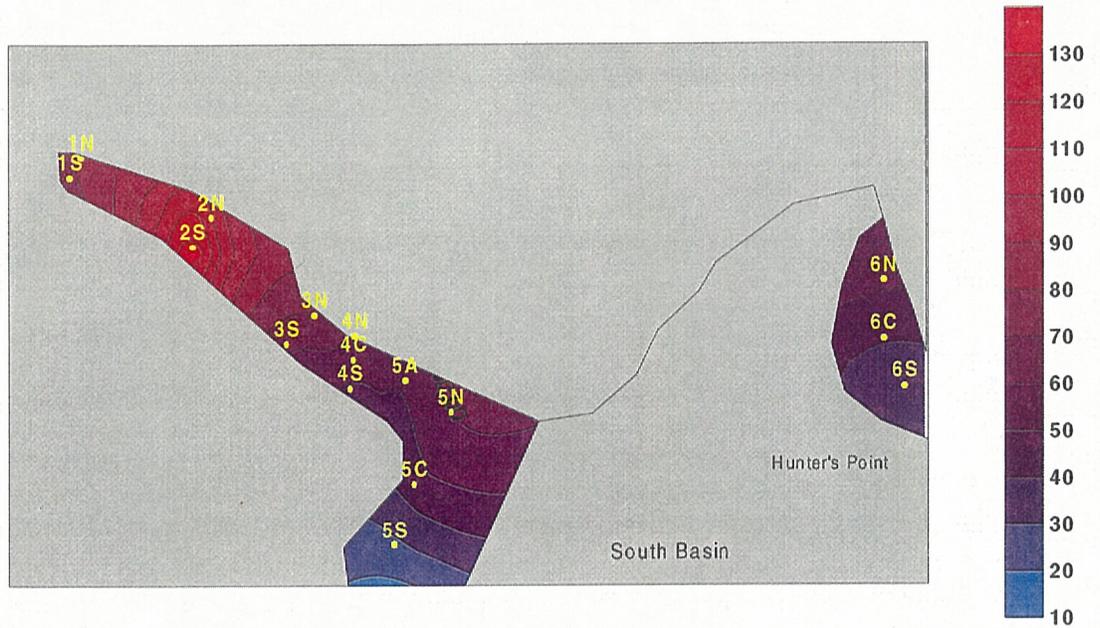


Figure 5-5. Distribution of Dieldrin and total Chlordane in Yosemite Creek and South Basin surface sediments.

Total DDT (ppb dry weight)



Total PCB (ppb dry weight)

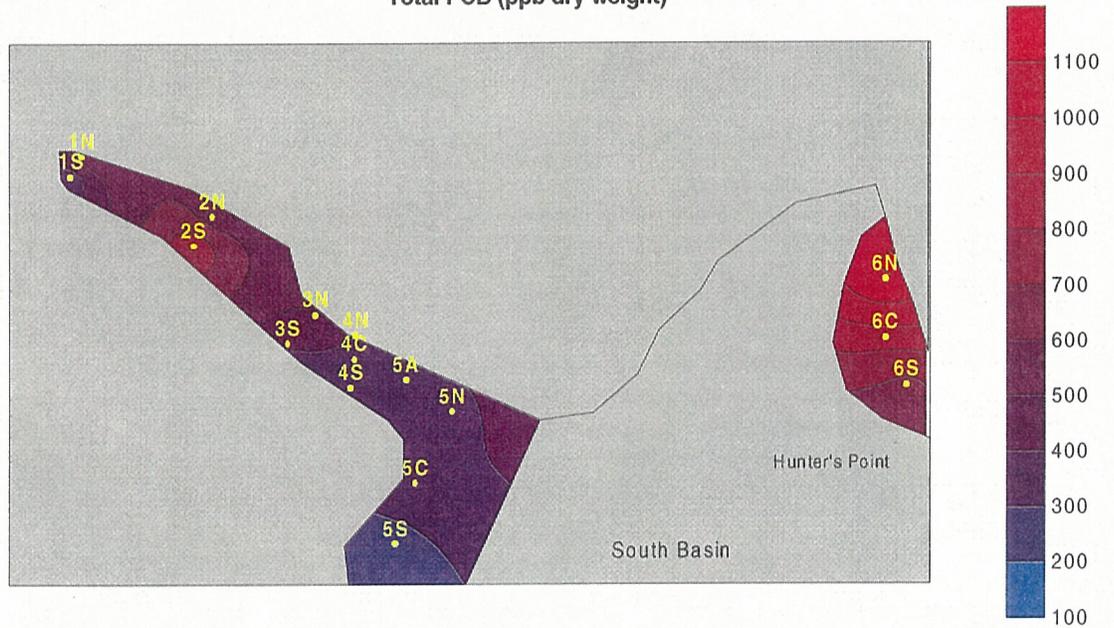


Figure 5-6. Distribution of total DDT and total PCB in Yosemite Creek and South Basin surface sediments.

Table 5-5. PCB in surface sediments of Yosemite Creek

Depth	Minimum	Minimum Station	Maximum	Maximum Station	Mean	Standard Deviation
Surface	243.78	5S	803.96	2S	435.25	141.33
0-1 ft	358.10	4C	2356.50	1N	888.24	833.52
1-2 ft.	271.44	1N	856.80	5N	528.72	243.05

#### 5.4.2 Subsurface sediment results

The vertical distribution of total PCB in sediments showed a clear elevation in the upper 1-ft. composite (Table 5-5). Surface- and deep-sediments (1'-2') had similar average concentrations (slightly greater in the deep segment). Maximum subsurface concentrations at the 0-1 and 1-2 ft core segments were highest at Stations 1N (creek origin) and 5N, respectively.

#### 5.4.3 Source identification of PCB

A preliminary evaluation of PCB sources in Yosemite Creek sediments is presented in Appendix D.

**SECTION 6**

**TOXIC HOT SPOT EVALUATION**

**SECTION 7**

**REFERENCES**

## 7.0 REFERENCES CITED

- Anderson, S.L., J.P. Knezovich, J. Jelinski and D.J. Steichen. 1995. The utility of using pore-water toxicity testing to develop site-specific marine sediment quality objectives for metals. Final Report. LBL-37615 UC-000. Lawrence Berkeley National Laboratory, University of California, Berkeley, California.
- Chapman, P.M, R.N. Dexter and E.R. Long. 1987. Synoptic measurements of sediment contamination, toxicity and infaunal community composition (the Sediment Quality Triad) in San Francisco Bay. *Marine Ecology Progress Series*. 37: 75-96.
- Chapman, P.M. 1996. A test of sediment effects concentrations: DDT and PCB in the Southern California Bight. *Envt. Toxicol. Chem.* 15(7): 1197-1198.
- CRWQCB (California Regional Water Quality Control Board), San Francisco Bay Region. Draft Final Regional Toxic Hot Spot Cleanup Plan. December 1998. 132 pp.
- CRWQCB (California Regional Water Quality Control Board), San Francisco Bay Region. Draft Final Regional Toxic Hot Spot Cleanup Plan. December 1998. 132 pp.
- Di Toro, D.M., C. Zarba, D.J. Hansen, W. 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 by using equilibrium partitioning. *Environ. Toxicol. Chem.* 10: 1541-1583.
- EMCON Associates. 1987. Confirmation Study Verification Step, Hunter's Point Naval Shipyard. Volumes I-IV. San Francisco, CA.
- EPA (U.S. Environmental Protection Agency). 1993. Technical basis for establishing sediment quality criteria for nonionic organic contaminants for the protection of benthic organisms by using equilibrium partitioning. EPA Office of Water, EPA-822-R-93-011, September, 1993.
- EPA (U.S. Environmental Protection Agency). 1995. Short term methods for estimating the chronic toxicity of effluents and receiving waters to west coast marine and estuarine organisms. Office of Research and Development. EPA/600/R-95/136. August 1995.
- ESA (Environmental Science Associates). 1987. Final Environmental Impact Statement: Homeporting Battleship battle Group/Cruise Destroyer Group, Volumes 1, 2 and 3. San Francisco, CA.
- Fairey, R., C. Bretz, S. Lamerdin, J. Hunt, B. Anderson, S. Tudor, C. Wilson, F. LeCaro, M. Stephenson, H. Puckett and E. Long. 1996. Chemistry, toxicity and benthic community conditions in sediment of the San Diego Bay region. Final Report, California State Water Resources Control Board.
- Hunt, J.W., B.S. Anderson, B.M. Phillips, J. Newman, R.S. Tjeerdma, K. Taberski, C.J. Wilson, M. Stephenson, H.M. Puckett, R. Fairey and J. Oakden. 1998. Sediment Quality and Biological Effects in San Francisco Bay. Bay Protection and Toxic Cleanup Program. Final Technical Report. California State Water Resources Control Board, San Francisco Bay Regional Water Quality Control Board, California Department of Fish and Game Marine Pollution Studies Laboratory, California State University Moss Landing Marine Laboratories, University of California, Santa Cruz Institute of Marine Sciences. August 1998. 188 pp. + Appendices.
- Knezovich, J.P., D.J. Steichen, J.A. Jelinski and S.L. Anderson. 1996. Sulfide tolerance of four marine species used to evaluate sediment and pore water toxicity. *Bull. Environ. Contam. Toxicol.* 57: 450-457.

- Lamberson, J.O., T.H. DeWitt and R.C. Swartz. 1992. Assessment of Sediment Toxicity to Marine Benthos. Chapter 9, pp. 183-203, *In: Sediment Toxicity Assessment*, G.A. Burton (Ed.), Lewis Publishers, Boca Raton, Fla.
- Landrum, P.F., S.R. Nihart, B.J.Eadie, and L.R. Herche. 1987. Reduction in bioavailability of organic contaminants to the amphipod *Pontoporeia hoyi* by dissolved organic matter of sediment interstitial waters. *Environ. Toxicol. Chem.*: 11-20.
- Long, E.R. and L.G. Morgan. 1990. The potential for biological effects of sediment-sorbed contaminants tested in the National Status and Trends Program. NOAA Tech. Mem. NOS OMA 45.
- Long, E.R., D.L. Mac Donald, S.L. Smith and F.D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentration in marine and estuarine sediments. *Environmental Management*. 19(1): 81-97.
- Long, E.R., L.J. Field and D.D. MacDonald. 1998. Predicting toxicity in marine sediments with numerical sediment quality guidelines. *Environmental Toxicology and Chemistry*. 4: 714-727.
- MacDonald, D.D., R.S. Carr, F.D. Calder and E.R. Long. 1996. Development and evaluation of sediment quality guidelines for Florida coastal waters. *Ecotoxicology* 5: 253-278.
- NOAA (U.S. National Oceanic and Atmospheric Administration. 1991. Contaminant Trends in the Southern California Bight: Inventory and Assessment. NOAA Tech. Mem. NOS ORCA 62. Seattle, Washington. October, 1991.
- Page, D.S., P.D. Boehm, G.S. Douglas and A.E. Bence. 1995. Identification of hydrocarbon sources in the benthic sediments of Prince William Sound and the Gulf of Alaska following the *EXXON VALDEZ* oil spill. Pp. 41-83 *In: Fate and Effects in Alaskan Waters*. ASTM STP 1219. P.G. Wells, J. N. Butler and J.S. Hughes (Eds.). American Society for Testing and Materials, Philadelphia, 1995.
- Pavlou, S., R. Kadeg, A. Turner, and M. Marchlik. 1987. Sediment quality criteria methodology validation: uncertainty analysis of sediment normalization theory for non-polar organic contaminants. SCD No. 14. U.S. Environmental Protection Agency, Washington, DC.
- Sauer, T. and P. Boehm. 1991. The use of defensible analytical chemical measurements for oil spill natural resource damage assessment. Pp. 363-369 *In: Int. 1991 Oil spill Conf. Proc.* March 4 to 7, 1991. San Diego, CA.
- Swartz, R.C., D.W. Shults, T.H. DeWitt, G.R. Ditsworth and J.O. Lamberson. 1990. Toxicity of fluoranthene in sediment tot marine amphipods: A test of the equilibrium partitioning approach to sediment quality criteria. *Env. Toxicol. Chem.* 9: 1071-1080.
- Swartz, R.C., F.A. Cole, J.O. Lamberson, S.P. Ferraro, D.W. Schults, W.A. Deben, H. Lee II and R.J. Ozretich. 1994. Sediment toxicity, contamination and amphipod abundance at a DDT- and Dieldrin-contaminated site in San Francisco Bay. *Environ. Toxicol. Chem.* 13: 949-962.
- USEPA/USACOE (U.S. Environmental Protection Agency/U.S. Army Corps of Engineers). 1991. Evaluation of Dredged Material Proposed for Ocean Disposal. Testing Manual. EPA-503/8-91/001. February 1991.

**APPENDIX A**

**SEDIMENT DATA**

Station, Replicate	1N, REP1		1S, REP1		2N, REP1		2N, REP2		2N, REP3		2S, REP1		3N, REP1		3S, REP1		4C, REP1		
	Depth	Surface	0-1 ft	1-2 ft	Surface	0-1 ft	1-2 ft	Surface	0-1 ft										
<b>TOXICITY</b>																			
Survival (%)		66.5										72.8	69.0					62.0	
<b>TOTAL ORGANIC CARBON (%)</b>																			
	2.3	3.9	1.3	2.0	2.4	2.0	1.6	2.2	0.0	2.3	2.6	2.7	2.4	2.6	2.4	2.6	2.4	1.8	
	0	0	9.5	0	0	11.1	17.2	0	0	1.8	2.2	3	2.3	4.2	0	4.2	0	1	
Gravel																			
Sand	3	6.4	70.1	2.5	6.6	12.4	51.2	6.9	6.7	22.8	16.1	5.8	15.4	46.9	8.5	16	16		
Silt	87	79	9.2	59.7	71	61.2	25.9	37.8	43.1	39.8	51.6	47.2	39.5	35.5	45.2	46.9			
Clay	10	14.6	11.2	37.8	22.4	15.3	5.7	55.3	50.2	35.6	30.1	44	42.8	13.4	46.3	36.1			
Fines (Silt + Clay)	97	93.6	20.4	97.5	93.4	76.5	31.6	93.1	93.3	75.4	81.7	91.2	82.3	48.9	91.5	83			
<b>METALS (µg g<sup>-1</sup> dry weight) (ppm)</b>																			
Aluminum	45050	45294	10622	50725	43308	50244	26639	46651	42820	36340	40282	34083	47459	29910	30320	33878			
Arsenic	9.7	10.4	7	9.2	9.8	9.5	11.6	9.6	8.8	8.3	9.1	11.4	11.7	10.7	9.1	10.4			
Cadmium	1.37	8.63	0.46	0.53	0.86	0.92	2.97	0.85	0.86	1.24	0.89	0.64	1.06	8	0.55	0.84			
Chromium	143	368	51	142	131	143	154	134	131	126	129	122	173	234	107	125			
Copper	108	146	445	109	103	92	57	96	100	79	112	113	100	116	97	87			
Iron	44136	44307	15918	47306	41575	43167	32185	41210	41462	36226	40756	41655	43250	36311	37683	37880			
Mercury	0.7	1.49	0.12	0.53	0.56	0.01	0.45	0.59	0.57	0.58	0.73	0.94	0.43	0.98	0.68	0.41			
Lead	168	811	38	132	137	134	266	135	144	155	144	156	159	636	129	119			
Nickel	93	108	29	98	94	92	65	98	95	78	87	93	94	76	87	85			
Selenium	0.96	1.52	0.16	0.38	0.41	0.45	0.55	0.38	0.4	0.38	0.35	0.33	0.53	1.55	0.29	0.4			
Silver	0.6	1.2	<0.1	0.5	0.5	<0.3	<0.3	0.5	0.6	0.5	<0.5	0.6	<0.5	0.9	0.4	<0.5			
Zinc	289	830	157	227	231	242	288	226	227	217	253	242	248	678	220	221			
Silver ERM Quotient	0.16	0.32	0.01	0.14	0.14	0.04	0.04	0.14	0.16	0.14	0.07	0.16	0.07	0.24	0.11	0.07			
Arsenic ERM Quotient	0.14	0.15	0.10	0.13	0.14	0.14	0.17	0.14	0.13	0.12	0.13	0.16	0.17	0.15	0.13	0.15			
Chromium ERM Quotient	0.39	0.99	0.14	0.38	0.35	0.39	0.42	0.36	0.35	0.34	0.35	0.33	0.47	0.63	0.29	0.34			
Cadmium ERM Quotient	0.14	0.90	0.05	0.06	0.09	0.10	0.31	0.09	0.09	0.13	0.09	0.07	0.11	0.83	0.06	0.09			
Copper ERM Quotient	0.40	0.54	1.65	0.40	0.38	0.34	0.21	0.36	0.37	0.29	0.41	0.42	0.37	0.43	0.36	0.32			
Lead ERM Quotient	0.77	3.72	0.17	0.61	0.63	0.61	1.22	0.62	0.66	0.71	0.66	0.72	0.73	2.92	0.59	0.55			
Mercury ERM Quotient	1.00	2.13	0.17	0.76	0.80	0.01	0.64	0.84	0.81	0.83	1.04	1.34	0.61	1.40	0.97	0.59			
Zinc ERM Quotient	0.70	2.02	0.38	0.55	0.56	0.59	0.70	0.55	0.55	0.53	0.62	0.59	0.60	1.65	0.54	0.54			

< = not detected at reported detection limit; \* = result between method reporting limit and reported detection limit

Station, Replicate	1N, REP1		2N, REP1		1S, REP1		2N, REP2		2N, REP3		2S, REP1		3N, REP1		3S, REP1		4C, REP1		
	Depth	Surface	0-1 ft	1-2 ft	Surface	0-1 ft													
PAHs (ng g <sup>-1</sup> dry weight) (ppb)																			
Naphthalene	48	560	80	38	46	54	46	48	54	80	120	52	220	74	49				
C1-Naphthalenes	52	420	27	48	52	50	54	61	65	74	110	63	280	71	47				
C2-Naphthalenes	73	710	65	88	76	75	69	70	75	100	120	99	410	91	78				
C3-Naphthalenes	50	490	79	38	50	48	49	48	56	77	100	84	290	80	50				
C4-Naphthalenes	43	650	88	53	45	48	49	49	42	72	91	68	220	63	48				
Acenaphthylene	28	350	73	26	40	42	35	34	36	78	120	43	76	120	48				
Acenaphthene	11	210*	15	7	12	11	11	12	12	29	31	17	54*	26	14				
Biphenyl	18	210*	13	13	16	14	16	15	15	21	30	17	54*	22	14				
Dibenzofuran	12	210*	11	8.9	12	8.6	10	11	11	18	24	12	54*	18	9.3				
Fluorene	19	210*	72	15	22	18	19	21	21	40	51	24	82	45	20				
C1-Fluorenes	21	240	59	17	19	30	21	18	20	30	44	25	89	33	24				
C2-Fluorenes	47	320	45	25	32	30	29	24	25	37	39	34	150	33	27				
C3-Fluorenes	65	1100	69	53	56	110	43	48	58	82	42	72	460	79	55				
Anthracene	66	1000	250	45	90	72	71	76	99	180	200	97	510	160	87				
Phenanthrene	140	740	300	190	200	100	140	160	150	400	450	180	340	460	180				
C1-Phenanthrenes/anthracenes	100	1000	400	180	120	95	100	110	120	260	300	140	390	260	140				
C2-Phenanthrenes/anthracenes	110	1500	200	130	110	120	91	100	100	230	230	150	500	170	110				
C3-Phenanthrenes/anthracenes	100	2200	120	89	84	210	80	83	110	170	150	110	760	100	110				
C4-Phenanthrenes/anthracenes	150	2900	180	110	200	190	200	190	220	380	330	140	800	250	150				
Dibenzothiophene	14	210*	49	11	17	12	15	14	16	30	34	16	54*	31	16				
C1-Dibenzothiophenes	13	210*	49	11	16	20	15	16	17	30	34	20	130	27	20				
C2-Dibenzothiophenes	31	650	64	28	32	53	40	34	38	78	78	47	290	54	38				
C3-Dibenzothiophenes	39	1100	43	32	37	120	36	32	41	55	66	49	690	41	48				
Fluoranthene	300	2600	950	270	410	190	340	350	310	840	890	350	580	790	390				
Pyrene	440	7100	1500	360	510	760	460	480	490	1000	1200	510	1500	1000	540				
C1-Fluoranthenes/pyrenes	200	4700	550	140	200	350	190	210	200	540	590	270	990	440	300				
C2-Fluoranthenes/pyrenes	180	2700	200	100	160	230	140	160	180	320	360	170	780	260	200				
C3-Fluoranthenes/pyrenes	130	1700	89	75	95	200	87	94	120	190	180	130	720	130	150				
Benzofl[anthracene	170	1800	530	130	190	170	180	200	170	540	630	250	400	500	240				
Chrysene	200	1600	520	160	260	180	220	250	210	690	920	280	420	670	270				
C1-Chrysenes	130	1600	260	88	150	190	130	140	150	320	370	170	440	270	150				
C2-Chrysenes	120	1200	100	73	130	110	120	130	150	260	250	140	520	180	140				
C3-Chrysenes	110	860	84	69	100	95	99	100	140	200	210	140	470	150	140				

< = not detected at reported detection limit; \* = result between method reporting limit and reported detection limit

Station, Replicate	1N, REP1		1S, REP1		2N, REP1		2N, REP2		2N, REP3		2S, REP1		3N, REP1		3S, REP1		4C, REP1			
	Depth	Surface	0-1 ft	1-2 ft	Surface	0-1 ft	1-2 ft	Surface	0-1 ft	Surface	0-1 ft	Surface	0-1 ft							
C4-Chrysenes	94	780	53	60	88	80	120	81	85	110	150	130	170	130	410	130	410	130	410	120
Benzo[b]fluoranthene	480	2500	760	380	480	410	520	430	450	440	950	560	1300	560	680	980	680	980	480	480
Benzo[k]fluoranthene	130	890	250	120	130	100	120	150	150	130	280	190	420	190	260	330	260	330	170	170
Benzo[e]pyrene	290	2000	420	230	300	230	310	270	300	270	580	320	780	320	510	600	510	600	300	300
Benzo[a]pyrene	340	2800	710	280	360	310	400	340	370	320	780	430	1000	430	670	810	670	810	410	410
Perylene	140	700	180	120	140	100	120	130	140	120	230	160	310	160	200	240	200	240	140	140
Indeno[1,2,3-c,d]pyrene	260	1500	420	220	330	240	260	280	310	270	500	310	660	310	400	530	400	530	300	300
Dibenzo[a,h]anthracene	37	280	50	28	45	28	38	40	44	40	82	41	100	41	69	81	69	81	42	42
Benzo[ghi]perylene	290	1700	340	250	370	210	220	320	360	310	540	270	720	270	400	570	400	570	300	300
Total PAH (41 analytes)	5504.65	55786.5	10330.7	4236.9	5974.3	5057.48	6497.8	5360.8	5924	5754	11680.65	6564.6	14032.6	6564.6	18399.35	11120.55	18399.35	11120.55	6316.8	6316.8
LMW PAH ERM Quotient	0.26	2.39	0.44	0.20	0.30	0.27	0.30	0.25	0.27	0.28	0.54	0.33	0.66	0.33	1.01	0.56	1.01	0.56	0.29	0.29
HMW PAH ERM Quotient	0.25	1.94	0.46	0.20	0.27	0.22	0.27	0.25	0.26	0.24	0.54	0.30	0.68	0.30	0.58	0.54	0.58	0.54	0.29	0.29
Total PAH ERM Quotient	0.07	0.58	0.13	0.06	0.08	0.07	0.08	0.07	0.08	0.07	0.15	0.09	0.19	0.09	0.20	0.15	0.20	0.15	0.08	0.08
LABs (ng g <sup>-1</sup> dry weight) (ppb)																				
C10B-Phenyl decanes	31	<35	<0.35	18	<1.3	<0.58	<0.6	<1.2	38	<1	<1.1	36	32	36	<8.9	16	<8.9	16	33	33
C11B-Phenyl undecanes	42	<35	<0.35	25	29	14	<0.6	30	30	16	<1.1	39	29	39	130	28	130	28	36	36
C12B-Phenyl dodecanes	30	<35	<0.35	32	<1.3	<0.58	<0.6	<1.2	19	<1	<1.1	<1.2	<1.2	<1.2	<8.9	<1.1	<8.9	<1.1	<1	<1
C13B-Phenyl tridecanes	110	<35	13	34	35	62	170	83	110	86	61	73	64	64	970	69	970	69	47	47
C14B-Phenyl tetradecanes	<1.3	<35	<0.35	25	77	30	<0.6	<1.2	130	120	75	44	44	45	<8.9	38	<8.9	38	36	36

< = not detected at reported detection limit; \* = result between method reporting limit and reported detection limit

APPENDIX A  
SEDIMENT DATA

Station, Replicate	1N, REP1		1S, REP1		2N, REP1		2N, REP2		2N, REP3		2S, REP1		3N, REP1		3S, REP1		4C, REP1		
	Depth	Surface	0-1 ft	1-2 ft	Surface	0-1 ft	1-2 ft	Surface	0-1 ft	1-2 ft	Surface	0-1 ft	1-2 ft	Surface	0-1 ft	Surface	0-1 ft	Surface	0-1 ft
TPHs (ng g <sup>-1</sup> dry weight) (ppb)	96	640	36	53	67	71	120	71	66	82	80	73	52	380	54	49			
Total Resolved Hydrocarbons	1400	7400	310	800	960	900	1600	900	920	1000	900	780	810	4200	580	540			
Total Petroleum Hydrocarbons	3	<11	0.65	1.8	2.9	3.1	3.5	3.1	3.3	2.5	2.8	3.2	3.7	39	2.3	1.4			
TPH <C8-C10	3.1	94	2.1	2.1	2.5	3	12	3	2.4	5.5	3.1	2.4	3.2	190	1.7	1.1			
TPH <C10-C12	20	250	8.6	10	13	13	50	13	13	19	14	12	13	230	8.9	8			
TPH <C12-C16	140	1200	47	77	87	84	260	84	85	120	81	66	72	660	51	49			
TPH <C16-C21	250	1400	60	140	160	150	330	150	160	180	150	120	130	720	91	91			
TPH <C21-C25	420	1900	84	240	280	260	440	260	270	300	260	230	230	960	170	160			
TPH <C25-C30	330	1400	62	190	220	210	320	210	210	230	220	190	190	740	140	130			
TPH <C30-C35	260	1100	45	140	190	180	230	180	180	170	170	160	170	640	120	100			
TPH <C35 +	<0.77	<10	<0.2	<0.34	<0.73	<0.7	<0.35	<0.7	<0.68	<0.58	<0.66	<0.69	<0.68	<5.2	<0.66	<0.3			
n-Nonane (C9)	<0.028	4.3*	<0.0076	0.14*	<0.027	<0.026	0.14*	<0.026	0.28*	0.24*	0.27*	0.29*	0.28*	2.2*	<0.024	0.13*			
n-Decane (C10)	<0.089	<1.2	<0.024	<0.039	<0.084	<0.08	<0.04	<0.08	<0.079	<0.068	<0.076	<0.08	<0.078	<0.6	<0.076	<0.035			
n-Undecane (C11)	<0.09	<1.2	<0.024	<0.039	<0.085	<0.08	<0.04	<0.08	<0.079	<0.068	<0.076	<0.08	<0.079	<0.6	<0.076	<0.035			
n-Dodecane (C12)	<0.12	<1.6	<0.032	<0.053	<0.11	<0.11	<0.054	<0.11	<0.11	<0.091	<0.1	<0.11	<0.1	<0.8	<0.1	<0.048			
n-Tridecane (C13)	<0.14	<1.9	0.085*	<0.063	<0.14	<0.13	0.26	<0.13	<0.13	<0.11	<0.12	<0.13	<0.13	2.2*	<0.12	<0.057			
Isoprenoid RRT 1380	<0.19	<2.5	<0.05	<0.082	<0.18	<0.17	<0.085	<0.17	<0.16	<0.14	<0.16	<0.17	<0.16	<1.2	<0.16	<0.074			
n-Tetradecane (C14)	0.32*	4.3*	0.085*	0.14*	0.3*	0.29*	0.16	0.29*	0.28*	0.24*	0.27*	0.29*	0.28*	2.2*	0.27*	0.13*			
Isoprenoid RRT 1470	<0.077	<1	<0.02	0.14*	<0.073	<0.069	0.14*	<0.069	<0.068	<0.058	<0.066	<0.069	<0.068	<0.52	<0.066	<0.03			
n-Pentadecane (C15)	0.32*	<0.53	0.085*	0.14*	0.3*	0.29*	<0.018	0.29*	0.28*	0.24*	0.27*	0.29*	0.28*	<0.27	0.27*	0.13*			
n-Hexadecane (C16)	<0.092	<1.2	0.085*	<0.04	<0.087	<0.082	0.27	<0.082	<0.081	<0.069	<0.078	<0.082	<0.081	<0.61	<0.078	<0.036			
Isoprenoid RRT 1650	7.2	9.9	0.4	1.8	2.1	2.2	1.5	2.1	2.1	1.6	1.2	0.59	0.76	2.2*	0.51	0.46			
n-Heptadecane (C17)	<0.12	4.3*	0.1	0.14*	<0.11	<0.1	0.61	<0.1	<0.1	<0.087	<0.098	<0.1	<0.1	<0.77	<0.098	<0.045			
Pristane	<0.11	<1.4	<0.028	0.14*	<0.1	<0.096	<0.048	<0.096	<0.094	<0.08	<0.09	<0.095	<0.094	<0.71	<0.09	<0.042			
n-Octadecane (C18)	0.32*	4.3*	0.085*	0.14*	0.3*	0.29*	0.63	0.63	0.28*	0.24*	0.27*	0.29*	0.28*	2.2*	0.27*	0.13*			
Phytane	0.32*	<0.68	<0.014	<0.022	<0.048	0.29*	<0.023	0.29*	0.28*	0.24*	0.27*	0.29*	0.28*	<0.34	0.27*	<0.02			
n-Nonadecane (C19)	<0.033	<0.43	<0.0087	<0.014	<0.031	<0.03	<0.015	<0.03	<0.029	0.24*	0.27*	0.29*	<0.029	<0.22	0.27*	<0.013			
n-Eicosane (C20)	<0.076	5.4	<0.02	<0.033	<0.072	<0.069	<0.034	<0.069	<0.068	0.24*	<0.065	<0.068	1.2	3	<0.065	0.99			
n-Henicosane (C21)	0.34	<0.63	0.2	0.2	0.3	0.29	0.54	0.29	0.3	0.24*	0.27*	0.29*	0.4	<0.32	0.27*	<0.019			
n-Docosane (C22)	0.32*	4.3*	0.17	0.17	0.3*	0.29*	0.44	0.44	0.28*	0.24*	0.27*	0.29*	0.28*	<0.24	0.27*	<0.014			
n-Tricosane (C23)	<0.029	4.3*	0.26	<0.013	<0.027	<0.026	<0.013	<0.026	<0.026	<0.022	<0.025	<0.026	0.28*	<0.19	<0.025	<0.011			
n-Tetracosane (C24)	<0.091	<1.2	0.14	<0.04	0.3*	0.29*	<0.041	0.29*	0.28*	<0.069	0.27*	0.29*	<0.08	<0.61	0.27*	<0.036			
n-Pentacosane (C25)	<0.048	<0.64	0.088	<0.021	<0.046	<0.043	<0.022	<0.043	<0.043	<0.036	0.27*	0.29*	<0.042	<0.32	0.27*	<0.019			
n-Hexacosane (C26)																			

< = not detected at reported detection limit; \* = result between method reporting limit and reported detection limit

Station, Replicate	1N, REP1		1S, REP1		2N, REP1		2N, REP2		2N, REP3		2S, REP1		3N, REP1		3S, REP1		4C, REP1		
	Surface	0-1 ft	1-2 ft	Surface	0-1 ft	1-2 ft	Surface	0-1 ft	1-2 ft	Surface	0-1 ft								
n-Heptacosane (C27)	0.47	<0.66	0.2	0.37	0.34	0.23	0.48	0.33	0.32	0.32	<0.038	0.49	0.48	0.28*	2.2*	0.36	0.24		
n-Octacosane (C28)	<0.057	<0.75	0.56	<0.053	<0.054	<0.025	1.3	<0.051	<0.05	<0.05	0.62	0.99	<0.051	<0.05	<0.38	0.91	0.62		
n-Nonacosane (C29)	0.93	<4.6	0.51	0.83	0.8	0.43	1.5	0.7	0.94	1.3	<0.094	1.7	1.3	0.47	<2.3	1.2	0.79		
n-Triacontane (C30)	<0.12	<1.6	0.14	<0.12	<0.12	<0.054	<0.056	<0.11	<0.11	<0.11	<0.094	<0.1	<0.11	<0.11	<0.82	0.28	<0.049		
n-Hentriacontane (C31)	1.3	10	0.81	1.2	1	0.67	0.37	1.4	0.86	2.1	2.1	2.1	1.8	0.8	<0.6	1.4	1.1		
n-Dotriacontane (C32)	0.36	4.3*	0.2	0.3*	0.33	<0.02	1.6	0.37	0.28	<0.034	<0.034	<0.038	0.56	0.28*	<0.3	<0.038	<0.018		
n-Tritriacontane (C33)	1.1	<0.79	0.43	0.86	0.89	0.56	1.4	1.1	0.88	0.24*	0.59	0.59	0.49	0.62	2.2*	0.33	0.27		
n-Tetracontane (C34)	0.57	<0.69	0.085	0.32	0.39	0.32	0.61	0.38	0.49	<0.039	<0.044	<0.044	<0.046	0.28*	<0.35	<0.044	<0.02		
n-Pentatriacontane (C35)	<0.048	<0.64	<0.013	0.3*	0.3*	<0.021	0.99	0.29*	<0.042	0.27	<0.041	<0.043	0.66	2.2*	2.2*	0.27*	<0.019		
n-Hexatriacontane (C36)	0.32*	<0.86	0.085*	<0.061	<0.061	<0.028	<0.029	<0.058	<0.057	0.29	0.28	0.28	0.3	<0.057	<0.43	0.27*	0.16		
n-Heptatriacontane (C37)	0.32*	<0.78	<0.016	0.3*	0.3*	<0.026	<0.026	0.29*	0.28*	<0.044	0.27*	0.29*	0.29*	0.28*	<0.39	<0.05	0.13*		
n-Octatriacontane (C38)	0.38	<0.7	<0.014	0.39	0.3*	0.16	<0.024	0.29*	0.33	<0.04	<0.045	<0.045	<0.047	0.28*	<0.35	<0.045	<0.021		
n-Nonatriacontane (C39)	0.32*	<0.67	<0.013	0.3*	0.3*	<0.022	<0.023	<0.046	0.28*	<0.038	0.27*	<0.045	<0.045	<0.044	<0.34	0.27*	<0.02		
n-Tetracontane (C40)	0.32*	<0.7	<0.014	0.3*	0.3*	<0.023	<0.024	<0.048	<0.047	0.24*	0.27*	0.29*	0.29*	<0.046	<0.35	0.27*	<0.021		

< = not detected at reported detection limit; \* = result between method reporting limit and reported detection limit

Station, Replicate	1N, REP1		1S, REP1		2N, REP1		2N, REP2		2N, REP3		2S, REP1		3N, REP1		3S, REP1		4C, REP1	
	Depth	Surface	0-1 ft	1-2 ft	Surface	0-1 ft	1-2 ft	Surface	Surface	Surface	Surface	Surface	Surface	Surface	0-1 ft	1-2 ft	Surface	0-1 ft
PESTICIDES (ng g <sup>-1</sup> dry weight) (ppb)																		
Aldrin	<0.26	<0.34	<0.14	<0.24	<0.24	<0.22	<0.16	<0.23	<0.23	0.71*	<0.2	<0.22	<0.22	<0.23	<0.23	<0.17	<0.22	<0.2
alpha-Chlordane	25	52	1.3	5.3	8.7	8.2	17	9.4	8.8	8.8	12	15	10	11	21	7.5	5.4	5.4
gamma-Chlordane	39	110	<0.13	9.2	20	18	38	19	18	18	27	27	17	22	39	12	10	10
cis-Nonachlor	4.2	15	1.1	2.1	3.6	3.2	3.7	3.2	2.9	2.9	5.6	3.1	3.2	3.5	2.6	2.7	2	2
2,4'-DDT	<0.4	<0.53	<0.21	<0.38	<0.38	<0.35	<0.24	<0.36	<0.36	<0.36	<0.3	<0.34	<0.36	<0.35	<0.27	<0.34	<0.32	<0.32
4,4'-DDT	1.1	<0.75	<0.3	<0.53	1.7	<0.49	<0.34	0.88	2.6	<0.43	<0.43	3.6	7.1	2.4	<0.38	4.5	1.1	1.1
2,4'-DDE	<0.4	<0.53	3.2	<0.38	<0.38	<0.35	28	<0.36	<0.36	<0.36	26	<0.34	<0.36	<0.35	<0.27	<0.34	<0.32	<0.32
4,4'-DDE	60	670	39	23	44	44	88	42	44	44	80	32	24	34	66	19	21	21
2,4'-DDD	<0.24	280	1	3	5.1	4.4	<0.15	4.2	4.4	4.4	4.1	5.9	3.7	4.6	39	2.8	3	3
4,4'-DDD	28	480	7.4	17	23	16	<0.34	23	27	27	32	29	25	29	130	26	17	17
Dieldrin	58	370	21	28	46	44	81	46	46	46	110	42	32	58	120	35	26	26
Endrin	<0.24	<0.32	<0.13	<0.23	<0.23	<0.21	<0.15	<0.22	<0.21	<0.21	<0.18	<0.2	<0.22	<0.21	<0.16	<0.2	<0.19	<0.19
Heptachlor	0.81*	<0.32	<0.13	<0.23	0.76*	<0.21	<0.15	<0.22	0.71*	1.1	1.1	<0.2	<0.22	<0.21	1.2	0.68*	<0.19	<0.19
Heptachlor Epoxide	<0.24	<0.32	<0.13	<0.23	<0.23	<0.21	<0.15	<0.22	<0.21	<0.21	<0.18	<0.2	<0.22	<0.21	<0.16	<0.2	<0.19	<0.19
lindane	<0.18	<0.23	<0.094	<0.17	<0.17	<0.15	<0.11	<0.16	<0.16	<0.16	<0.13	<0.15	<0.16	<0.16	<0.12	<0.15	<0.14	<0.14
Mirex	<0.12	<0.16	<0.064	<0.11	<0.11	<0.1	<0.074	<0.11	<0.11	<0.11	<0.091	<0.1	<0.11	<0.11	<0.081	<0.1	<0.096	<0.096
trans-Nonachlor	10	31	1.1	3.4	5.9	5.2	7	6.2	5.8	8.4	8.4	7.1	6.8	6.6	6.2	4.4	4.4	4.6
DDT ERM Quotient	0.04	0.36	0.04	0.02	0.03	0.03	0.07	0.03	0.06	0.06	0.06	0.03	0.02	0.03	0.09	0.02	0.02	0.02
Dieldrin Quotient	7.25	46.25	2.63	3.50	5.75	5.50	10.13	5.75	5.75	13.75	13.75	5.25	4.00	7.25	15.00	4.38	3.25	3.25

< = not detected at reported detection limit; \* = result between method reporting limit and reported detection limit

Station, Replicate	1N, REP1		2N, REP1		1S, REP1		2N, REP2		2N, REP3		2S, REP1		3N, REP1		3S, REP1		4C, REP1		
	Depth	Surface	0-1 ft	1-2 ft	Surface	0-1 ft	1-2 ft	Surface	0-1 ft										
PCBs and Aroclors (ng g <sup>-1</sup> dry weight) (ppb)																			
PCB 8	1.5	<0.09	<0.16	<0.15	<0.16	<0.16	1.4	<0.15	<0.15	<0.15	<0.13	<0.14	1.7	2.2	1.5	<0.14	1.4		
PCB 18	1.5	7.2	1.3	1.3	1.6	1.6	2.1	1.4	1.6	3	1.6	3	2.5	2.2	2.4	2.5	1.9		
PCB 24	5	9.2	1.4	3.8	5.3	5.3	3.2	4.6	5.2	7	3.3	7	6	4.9	3.7	6.3	3.8		
PCB 44	8	67	3.9	3.5	6.6	6.6	12	6	6.8	19	3.2	19	4.8	6.7	13	6.2	5.1		
PCB 52	16	77	8.9	5.9	13	13	24	12	13	36	6.5	36	8.4	15	21	11	11		
PCB 66	<0.13	230	15	16	24	24	39	23	24	52	23	23	19	22	24	24	18		
PCB 77	<0.19	<0.26	<0.1	<0.18	<0.18	<0.18	<0.17	<0.17	<0.17	<0.15	<0.16	<0.17	<0.17	<0.17	<0.13	<0.16	<0.15		
PCB 101	50	130	22	27	46	46	56	46	46	83	37	37	30	38	37	33	28		
PCB 105	28	140	7.8	12	20	20	26	20	21	38	16	16	11	14	15	13	11		
PCB 118	51	80	19	26	43	43	57	44	45	95	31	31	27	34	8.2	33	25		
PCB 126	<0.3	<0.39	<0.16	<0.28	<0.28	<0.28	<0.18	<0.27	<0.26	<0.22	<0.25	<0.27	<0.27	<0.26	<0.2	<0.25	<0.24		
PCB 128	19	89	7.4	9.9	16	16	19	15	14	25	12	12	10	12	11	9.7	9		
PCB 138	120	280	56	65	110	110	140	110	110	150	110	110	85	100	89	78	71		
PCB 153	82	350	37	50	74	74	84	72	73	100	70	70	59	66	40	53	51		
PCB 170	52	280	26	32	48	48	69	47	47	55	50	50	41	44	22	32	35		
PCB 180	69	390	41	42	65	65	98	62	66	76	67	67	56	60	30	49	48		
PCB 187	42	160	19	27	39	39	41	38	39	48	39	39	32	35	17	28	28		
PCB 195	9.9	36	3.6	6.3	9	9	9.1	9.5	9.6	9.3	9.4	9.4	6.7	5.1	3.3	5.6	5.3		
PCB 206	5.1	18	2.1	3.5	4.7	4.7	5	4.9	5	5.3	9.5	9.5	4.3	4.3	1.8	4	3.9		
PCB 209	3.6	7.6	0.77	2.5	2.9	2.9	2.7	3.4	2.8	2.3	4.1	4.1	1.7	2.8	1.6	1.8	1.7		
Total PCBs (NOAA 18)	560	2400	270	330	530	530	690	520	530	800	490	490	410	470	340	390	360		
Total Aroclor 1016	<16	<21	<8.5	<15	<15	<15	<9.8	<14	<14	<12	<14	<14	<14	<100	<14	<100	<100		
Total Aroclor 1221	<16	<21	<8.5	<15	<15	<15	<9.8	<14	<14	<12	<14	<14	<14	<100	<14	<100	<100		
Total Aroclor 1232	<16	<21	<8.5	<15	<15	<15	<9.8	<14	<14	<12	<14	<14	<14	<100	<14	<100	<100		
Total Aroclor 1242	<16	<21	<8.5	<15	<15	<15	<9.8	<14	<14	<12	<14	<14	<14	<100	<14	<100	<100		
Total Aroclor 1248	<16	<21	<8.5	<15	<15	<15	<9.8	<14	<14	<12	<14	<14	<14	<100	<14	<100	<100		
Total Aroclor 1254	900	14000	290	290	510	510	790	480	640	670	550	550	440	570	920	480	500*		
Total Aroclor 1260	670	10000	270	420	620	620	630	600	620	350	690	690	540	500*	500*	440	500*		

< = not detected at reported detection limit; \* = result between method reporting limit and reported detection limit

Station, Replicate	4N, REP1		5A, REP1		5C, REP1		5C, REP2		5C, REP3		5N, REP1		5S, REP1		6N, REP1		6S, REP1		Reference	
	Depth	1-2 ft	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	0-1 ft	1-2 ft	Surface	Surface	Surface	Surface	Surface	Surface		(Paradise)
<b>TOXICITY</b>																				
Survival (%)	1.7	1.6	1.9	1.7	1.9	1.7	1.7	1.7	1.7	1.7	51.1	2.0	1.5	1.7	2.2	1.3	1.2		65.0	
<b>TOTAL ORGANIC CARBON (%)</b>																				
Gravel	3.4	0	2.5	2.9	0	0	0	0	0	0	1.4	3.6	0	5.8	3.8	6.4	0			
Sand	59.6	7.9	7.5	15.889	7.1	7.8	7.8	7.8	7.8	7.8	15.9	8.3	4.9	20	25.4	51.2	9.7			
Silt	29.8	55.4	46.2	34.5	40.4	56.3	44.5	44.5	44.5	37.2	37	45	45.7	32.2	31.8	18.8	39.4			
Clay	7.2	36.7	43.8	46.7	52.5	35.9	47.7	45.5	45.5	29.2	29.2	43.1	49.4	42	39	23.6	50.9			
Fines (Silt + Clay)	37	92.1	90	81.2	92.9	92.2	92.2	92.2	92.2	82.7	66.2	88.1	95.1	74.2	70.8	42.4	90.3			
<b>METALS (<math>\mu\text{g g}^{-1}</math> dry weight) (ppm)</b>																				
Aluminum	9499	39869	44826	34720	41070	33737	23647	34812	29874	33376	37279	34890	37641	26783	43953					
Arsenic	8.1	8.2	9	9.2	10	10.6	9	9	8.8	11.7	8.9	10.6	11.5	9.9	10.1					
Cadmium	1.75	0.6	0.56	0.58	0.68	0.71	0.9	0.45	1.83	2.28	0.41	0.58	0.59	0.33	0.28					
Chromium	106	120	126	114	122	118	103	111	165	152	114	146	168	146	103					
Copper	90	99	103	91	110	98	101	82	108	60	141	163	236	148	48					
Iron	20496	38151	41183	39800	39897	39153	33775	35765	30682	34693	42971	38218	37177	30179	37331					
Mercury	0.65	0.63	0.61	0.55	0.59	0.58	0.55	0.66	0.95	0.57	0.53	1.03	1.14	0.81	0.35					
Lead	225	119	144	109	117	114	127	101	244	167	92	114	153	116	26					
Nickel	50	85	90	85	86	86	78	79	74	70	95	118	116	140	82					
Selenium	0.31	0.33	0.32	0.29	0.29	0.29	0.28	0.28	0.29	0.55	0.31	0.31	0.29	0.24	0.29					
Silver	2	0.5	<0.5	0.4	<0.5	0.5	0.5	<0.5	0.7	<0.3	<0.5	0.5	0.6	0.3	<0.5					
Zinc	313	214	235	200	211	206	214	186	316	233	197	232	276	192	120					
Silver ERM Quotient	0.54	0.14	0.07	0.11	0.07	0.14	0.14	0.07	0.19	0.04	0.07	0.14	0.16	0.08	0.07					
Arsenic ERM Quotient	0.12	0.12	0.13	0.13	0.14	0.15	0.13	0.13	0.13	0.17	0.13	0.15	0.16	0.14	0.14					
Chromium ERM Quotient	0.29	0.32	0.34	0.31	0.33	0.32	0.28	0.30	0.45	0.41	0.31	0.39	0.45	0.39	0.28					
Cadmium ERM Quotient	0.18	0.06	0.06	0.06	0.07	0.07	0.09	0.05	0.19	0.24	0.04	0.06	0.06	0.03	0.03					
Copper ERM Quotient	0.33	0.37	0.38	0.34	0.41	0.36	0.37	0.30	0.40	0.22	0.52	0.60	0.87	0.55	0.18					
Lead ERM Quotient	1.03	0.55	0.66	0.50	0.54	0.52	0.58	0.46	1.12	0.77	0.42	0.52	0.70	0.53	0.12					
Mercury ERM Quotient	0.93	0.90	0.87	0.79	0.84	0.83	0.79	0.94	1.36	0.81	0.76	1.47	1.63	1.16	0.50					
Zinc ERM Quotient	0.76	0.52	0.57	0.49	0.51	0.50	0.52	0.45	0.77	0.57	0.48	0.57	0.67	0.47	0.29					

< = not detected at reported detection limit; \* = result between method reporting limit and reported detection limit

APPENDIX A  
SEDIMENT DATA

Station, Replicate	4N, REP1		5A, REP1		5C, REP1		5C, REP2		5C, REP3		5N, REP1		5S, REP1		6C, REP1		6N, REP1		6S, REP1		Reference (Paradise)
	Depth	1-2 ft	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	0-1 ft	1-2 ft	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	
PAHs (ng g <sup>-1</sup> dry weight) (ppb)																					
Naphthalene		140	77	81	63	63	56	67	67	51	150	160	40	25	67	36	21				
C1-Naphthalenes		220	72	71	47	66	73	160	160	50	230	150	30	17	41	22	11				
C2-Naphthalenes		310	92	96	67	80	97	190	190	66	250	190	45	28	61	38	20				
C3-Naphthalenes		230	72	74	65	59	68	91	91	53	230	200	47	37	61	41	19				
C4-Naphthalenes		160	67	64	50	50	52	80	80	42	160	260	32	38	58	42	15				
Acenaphthylene		57	78	97	49	70	47	69	69	52	67	120	42	29	46	62	19				
Acenaphthene		38	23	20	18	12	16	23	23	14	24*	46	9.9	11	17	18	7				
Biphenyl		31	30	20	15	35	18	24	24	14	38	35	13	7.5	15	14	6.6				
Dibenzofuran		21	15	14	15	12	11	14	14	9.9	24*	18	8.5	9	16	12	4.1				
Fluorene		50	34	34	28	24	23	29	29	22	37	59	18	16	26	68	10				
C1-Fluorenes		54	32	32	27	24	23	29	29	21	56	97	21	15	24	30	9.5				
C2-Fluorenes		64	36	33	28	24	30	31	31	24	75	150	23	19	32	22	13				
C3-Fluorenes		160	67	63	58	47	57	58	58	48	140	270	40	50	85	64	16				
Anthracene		160	140	140	110	96	81	95	95	91	150	220	60	76	110	390	37				
Phenanthrene		240	320	320	240	190	190	180	180	210	200	230	130	140	220	720	83				
C1-Phenanthrenes/anthracenes		240	230	220	170	140	150	150	150	140	240	340	100	97	160	230	51				
C2-Phenanthrenes/anthracenes		270	170	160	140	110	110	140	140	110	260	490	89	92	160	110	36				
C3-Phenanthrenes/anthracenes		290	110	100	100	74	86	110	110	73	270	520	60	69	150	92	22				
C4-Phenanthrenes/anthracenes		350	250	240	130	160	110	150	150	160	300	570	91	110	230	200	60				
Dibenzothiophene		28	24	25	19	16	15	18	18	16	24	36	12	11	20	37	6.4				
C1-Dibenzothiophenes		46	26	27	20	18	16	20	20	17	45	63	13	14	22	22	5.4				
C2-Dibenzothiophenes		130	58	53	39	42	30	47	47	40	110	200	23	27	52	34	9.9				
C3-Dibenzothiophenes		170	42	46	55	31	32	48	48	32	130	250	26	55	95	90	8.3				
Fluoranthene		400	710	670	420	370	360	360	360	460	370	640	290	380	570	1300	200				
Pyrene		950	940	910	540	530	500	520	520	610	820	1200	400	410	640	1500	260				
C1-Fluoranthenes/pyrenes		580	420	390	280	220	230	300	300	260	530	910	190	250	390	500	91				
C2-Fluoranthenes/pyrenes		490	250	240	150	170	160	210	210	180	430	510	120	160	240	210	51				
C3-Fluoranthenes/pyrenes		360	130	110	110	98	110	160	160	90	410	340	82	97	170	120	30				
Benzo[a]anthracene		350	470	470	280	250	220	230	230	290	260	610	170	240	390	690	96				
Chrysene		400	580	580	330	300	250	330	330	360	280	620	200	320	500	680	110				
C1-Chrysenes		360	270	260	170	160	120	170	170	170	250	500	97	120	220	210	42				
C2-Chrysenes		380	190	180	130	130	110	160	160	120	310	300	80	88	160	130	32				
C3-Chrysenes		350	160	140	130	100	110	160	160	100	320	210	74	87	140	110	28				

< = not detected at reported detection limit; \* = result between method reporting limit and reported detection limit

APPENDIX A  
SEDIMENT DATA

Station, Replicate	4N, REP1		5A, REP1		5C, REP1		5C, REP2		5C, REP3		5N, REP1		5S, REP1		6C, REP1		6N, REP1		6S, REP1		Reference (Paradise)
	Depth	1-2 ft	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	0-1 ft	1-2 ft	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	
C4-Chrysenes	310	120	120	100	98	92	150	85	270	160	70	67	130	89	21						
Benzo[b]fluoranthene	820	890	950	560	590	590	580	640	560	1200	380	500	760	910	210						
Benzo[k]fluoranthene	240	280	340	150	160	140	160	170	170	400	97	140	270	330	56						
Benzo[e]pyrene	540	540	580	320	380	330	370	380	420	780	220	250	430	510	120						
Benzo[a]pyrene	620	730	780	430	480	440	480	500	520	1100	300	340	560	780	200						
Perylene	180	220	240	150	160	140	160	160	160	300	120	100	170	200	78						
Indeno[1,2,3,-c,d]pyrene	380	480	520	320	340	290	440	320	320	630	260	240	400	440	170						
Dibenzo[a,h]anthracene	66	74	81	41	48	44	53	47	51	90	28	34	58	67	18						
Benzo[g,h,i]perylene	350	520	550	280	380	320	440	340	350	560	250	200	340	340	190						
Total PAH (41 analytes)	11706.1	10176.8	10254.65	6508.795	6545.1	6107.285	7352.65	6733.55	10623.95	15888.5	4469.3	5072.325	8399.78	11606.18	2594.34						
LMW PAHERM Quotient	0.67	0.47	0.49	0.33	0.34	0.32	0.42	0.32	0.59	0.75	0.21	0.21	0.37	0.61	0.11						
HMW PAHERM Quotient	0.46	0.49	0.51	0.31	0.31	0.29	0.33	0.33	0.38	0.68	0.21	0.25	0.42	0.58	0.13						
Total PAHERM Quotient	0.15	0.14	0.14	0.09	0.09	0.09	0.10	0.09	0.12	0.20	0.06	0.07	0.12	0.17	0.03						
LABs (ng g <sup>-1</sup> dry weight) (ppb)																					
C10B-Phenyl decanes	68	<1.2	<1.1	<0.53	<1.1	18	<1.1	<1.1	120	73	<0.6	<0.55	<0.52	<0.48	26						
C11B-Phenyl undecanes	<3.4	<1.2	<1.1	17	20	25	25	<1.1	120	<1	24	20	15	40	20						
C12B-Phenyl dodecanes	<3.4	<1.2	<1.1	<0.53	<1.1	<0.57	<1.1	<1.1	<3.9	<1	<0.6	<0.55	<0.52	7.7	37						
C13B-Phenyl tridecanes	48	84	64	47	85	45	70	55	180	80	43	36	78	48	18						
C14B-Phenyl tetradecanes	<3.4	52	48	<0.53	32	72	<1.1	39	200	<1	<0.6	<0.55	<0.52	<0.48	<0.28						

< = not detected at reported detection limit; \* = result between method reporting limit and reported detection limit

Station, Replicate	4N, REP1		5A, REP1		5C, REP1		5C, REP2		5C, REP3		5N, REP1		5S, REP1		6N, REP1		6S, REP1		Reference (Paradise)
	1-2 ft	Surface	0-1 ft	1-2 ft	1-2 ft	Surface	1-2 ft	Surface	1-2 ft	Surface									
TPHs (ng g <sup>-1</sup> dry weight) (ppb)	100	60	58	44	51	55	51	46	99	110	31	60	52	40	15				
Total Resolved Hydrocarbons	1500	670	590	560	610	640	740	520	1400	1200	350	440	550	320	120				
Total Petroleum Hydrocarbons	3.1	1.8	1.8	2.6	1.9	1.9	4.4	2.1	<2.4	2.6	2.4	2.2	3.3	1.9	1.4				
TPH <C8-C10	7.5	1.7	1.8	1.9	1.8	1.8	1.5	1.5	4.1	13	0.99	1.2	1.6	1.2	0.68				
TPH <C10-C12	34	9.8	8.9	8.1	9.5	10	12	7.6	29	45	4.4	5.7	7.9	4.4	2.6				
TPH <C12-C16	140	60	50	46	57	59	68	48	150	190	30	40	57	30	16				
TPH <C16-C21	240	110	92	87	100	110	120	86	250	240	54	66	94	48	21				
TPH <C21-C25	420	200	170	160	180	190	220	150	410	330	100	120	160	87	34				
TPH <C25-C30	360	160	150	140	140	150	180	130	320	240	88	110	130	75	28				
TPH <C30-C35	320	130	120	120	120	120	140	100	280	180	71	92	100	69	21				
TPH <C35 +	<1.9	<0.67	<0.64	<0.3	<0.65	<0.66	<0.66	<0.63	<2.2	<0.6	<0.34	<0.32	<0.3	<0.28	<0.16				
n-Nonane (C9)	0.81*	0.28*	0.26*	0.13*	0.27*	0.27*	0.27*	<0.023	0.94*	0.25*	<0.013	0.13*	0.12*	0.11*	<0.0059				
n-Decane (C10)	<0.22	<0.077	<0.073	<0.035	<0.075	<0.076	<0.076	<0.072	<0.26	0.25*	<0.04	<0.036	<0.035	<0.032	<0.018				
n-Undecane (C11)	<0.22	<0.078	<0.074	<0.035	<0.075	<0.076	<0.076	<0.072	<0.26	<0.07	<0.04	<0.036	<0.035	<0.032	<0.018				
n-Dodecane (C12)	<0.3	<0.1	<0.099	<0.048	<0.1	<0.1	<0.1	<0.098	<0.35	<0.094	<0.054	<0.049	<0.047	<0.043	<0.025				
n-Tridecane (C13)	<0.36	<0.13	<0.12	<0.057	<0.12	<0.12	<0.12	<0.12	<0.42	0.32	<0.065	<0.059	<0.057	<0.052	<0.03				
Isoprenoid RRT 1380	<0.47	<0.16	<0.15	<0.074	<0.16	<0.16	<0.16	<0.15	<0.55	<0.14	<0.083	<0.076	<0.073	<0.067	<0.039				
n-Tetradecane (C14)	0.81*	0.28*	0.26*	0.13*	0.27*	<0.03	0.27*	0.26*	<0.1	0.34	0.14*	0.13*	0.12*	0.11*	0.067*				
Isoprenoid RRT 1470	<0.19	<0.067	<0.063	0.13*	<0.065	<0.066	<0.066	<0.063	<0.22	<0.06	<0.034	<0.032	0.12*	0.11*	<0.016				
n-Pentadecane (C15)	<0.1	0.28*	0.26*	0.13*	0.27*	0.27*	0.27*	0.26*	<0.12	<0.031	0.14*	0.13*	0.12*	0.11*	0.067*				
n-Hexadecane (C16)	<0.23	<0.08	<0.075	<0.036	<0.077	<0.078	<0.078	<0.074	<0.27	0.38	<0.041	<0.037	<0.036	<0.033	<0.019				
Isoprenoid RRT 1650	0.9	0.75	0.44	0.49	0.29	0.31	0.32	0.51	0.94*	0.25*	0.15	0.17	0.28	0.12	0.067*				
n-Heptadecane (C17)	<0.29	<0.1	<0.094	0.13*	<0.096	<0.098	<0.098	<0.093	<0.34	0.88	<0.051	0.13*	0.12*	0.11*	0.067*				
Pristane	<0.27	<0.092	<0.087	0.13*	<0.089	<0.09	<0.09	<0.086	<0.31	<0.083	<0.047	<0.043	0.12*	0.11*	<0.022				
n-Octadecane (C18)	0.81*	0.28*	0.26*	0.13*	0.27*	0.27*	0.27*	0.26*	0.94*	0.66	0.14*	0.13*	0.12*	0.11*	0.067*				
Phytane	<0.13	0.28*	0.26*	0.13*	0.27*	0.27*	0.27*	0.26*	<0.15	<0.04	<0.023	0.13*	0.12*	0.11*	0.067*				
n-Nonadecane (C19)	<0.082	0.28*	0.26*	<0.013	0.27*	0.27*	0.27*	0.26*	0.94*	<0.026	<0.015	0.13*	<0.013	<0.012	0.067*				
n-Eicosane (C20)	0.9	0.78	<0.063	<0.03	<0.064	<0.065	<0.065	<0.062	1.2	1	<0.034	<0.031	<0.03	0.11*	0.067*				
n-Henicosane (C21)	<0.12	0.28*	0.26*	0.44	0.27*	0.27*	0.27*	0.26*	<0.14	<0.037	0.14	0.24	0.38	0.22	0.087				
n-Docosane (C22)	<0.09	0.28*	0.26*	0.14	0.27*	0.27*	0.27*	0.26*	<0.1	0.28	0.14*	0.22	0.22	0.13	0.087				
n-Tricosane (C23)	<0.073	<0.025	<0.024	0.13	<0.024	<0.025	<0.025	<0.024	<0.085	<0.023	0.14*	0.27	0.16	0.24	0.1				
n-Tetracosane (C24)	<0.23	0.28*	0.26	0.13*	0.27*	<0.077	<0.077	0.26*	<0.26	<0.071	0.14*	0.46	0.18	0.14	0.078				
n-Pentacosane (C25)	<0.12	0.28*	0.26*	<0.019	0.27*	0.27*	<0.041	0.26*	<0.14	<0.038	0.14*	0.62	0.16	0.14	0.067*				
n-Hexacosane (C26)																			

< = not detected at reported detection limit; \* = result between method reporting limit and reported detection limit

Station, Replicate	4N, REP1		5A, REP1		5C, REP1		5C, REP3		5N, REP1		5S, REP1		6C, REP1		6N, REP1		6S, REP1		Reference (Paradise)
	Depth	1-2 ft	Surface	Surface	Surface	Surface	Surface	Surface	0-1 ft	1-2 ft	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	
n-Heptacosane (C27)		<0.12	0.46	0.21	0.35	0.32	0.27*	0.31	<0.14	<0.039	0.2	1.2	0.36	0.24	0.16				
n-Octacosane (C28)		0.81*	0.99	<0.022	0.63	0.62	<0.048	0.56	0.94*	1.3	<0.025	1.5	0.76	<0.02	<0.012				
n-Nonacosane (C29)		0.97	1.1	0.39	1.2	0.85	0.35	1	<1	1	0.35	2.3	0.79	0.43	0.37				
n-Triacontane (C30)		<0.31	0.3	<0.049	0.28	<0.1	<0.1	0.28	<0.36	<0.097	<0.055	1.8	0.3	0.25	0.076				
n-Hentriacontane (C31)		2.1	1.6	0.53	1.4	1.4	0.78	1.3	2.3	2.1	0.51	3	0.9	0.69	0.43				
n-Dotriacontane (C32)		0.81*	<0.039	0.14	<0.038	0.27*	0.27*	0.48	0.94*	<0.035	0.14*	1.9	0.35	0.28	0.094				
n-Tritriacontane (C33)		<0.15	0.37	0.45	0.32	0.27*	0.7	0.34	<0.17	0.34	0.4	2.4	0.75	0.48	0.16				
n-Tetracontane (C34)		<0.13	<0.045	0.17	<0.044	<0.044	0.32	<0.042	<0.15	<0.041	0.14	1.7	0.43	0.3	0.067*				
n-Pentatriacontane (C35)		<0.12	<0.042	<0.039	0.13*	<0.04	0.27*	0.52	<0.14	<0.037	0.38	1.7	0.25	0.27	<0.0099				
n-Hexatriacontane (C36)		0.81*	0.28*	0.13*	0.27*	0.27*	0.27*	0.26*	<0.19	<0.05	0.14*	1.2	0.31	0.25	0.067*				
n-Heptatriacontane (C37)		0.81*	0.28*	0.14	0.27*	0.27*	0.27*	0.26*	<0.17	<0.046	0.14*	1.3	0.4	0.3	0.067*				
n-Octatriacontane (C38)		0.81*	0.28*	0.16	<0.044	0.27*	0.29	<0.043	<0.16	<0.042	0.15	1	0.46	0.33	0.067				
n-Nonatriacontane (C39)		<0.13	<0.044	<0.02	0.27*	<0.043	0.27*	<0.041	<0.15	<0.039	0.14*	0.45	0.22	0.14	<0.01				
n-Tetracontane (C40)		<0.13	0.28*	<0.021	0.27*	0.27*	0.27*	0.26*	<0.15	<0.041	0.14*	0.38	0.21	0.14	0.067*				

< = not detected at reported detection limit; \* = result between method reporting limit and reported detection limit

Station, Replicate	Depth 1-2 ft		4N, REP1		5A, REP1		5C, REP1		5C, REP2		5C, REP3		5N, REP1		5S, REP1		6S, REP1		6N, REP1		6S, REP1		Reference (Paradise)
	Surface	1-2 ft	Surface	1-2 ft	Surface	1-2 ft	Surface	1-2 ft	Surface	1-2 ft	Surface	1-2 ft	Surface	1-2 ft	Surface	1-2 ft	Surface	1-2 ft	Surface	1-2 ft	Surface	1-2 ft	
PESTICIDES (ng g <sup>-1</sup> dry weight) (ppb)																							
Aldrin	1.8	<0.22	<0.21	<0.2	<0.22	<0.22	<0.22	<0.22	<0.22	<0.22	<0.22	<0.22	<0.19	0.63*	<0.23	<0.21	<0.2	<0.18	<0.21	<0.2	<0.18	<0.21	<0.21
alpha-Chlordane	7.1	7.8	6	5	5.1	5.5	7.2	6.4	14	5.4	2.7	2.4	1.6	1.3	2.4	2.4	1.6	1.3	2.4	1.6	1.3	2.4	<0.2
gamma-Chlordane	15	14	11	10	12	14	17	12	27	15	4.7	3.9	3.8	2.2	4.7	3.9	3.8	2.2	4.7	3.9	3.8	2.2	<0.2
cis-Nonachlor	2.2	2.9	<0.18	1.9	2.9	2.9	4.3	2.3	4.4	3.4	1.4	4.8	5.4	3.5	1.4	4.8	5.4	3.5	1.4	4.8	5.4	3.5	0.67*
2,4'-DDT	<0.25	<0.35	<0.33	<0.32	<0.34	<0.34	<0.34	<0.33	<0.29	<0.31	<0.36	<0.33	<0.31	<0.29	<0.36	<0.33	<0.31	<0.29	<0.36	<0.33	<0.31	<0.29	<0.33
4,4'-DDT	24	36	2.9	2.3	3	0.91	4.7	23	3.6	36	1.1	1.4	3.4	2	1.1	1.4	3.4	2	1.1	1.4	3.4	2	<0.47
2,4'-DDE	<0.25	<0.35	<0.33	<0.32	<0.34	<0.34	0.34	0.33	<0.29	<0.31	<0.36	<0.33	<0.31	<0.29	<0.36	<0.33	<0.31	<0.29	<0.36	<0.33	<0.31	<0.29	<0.33
4,4'-DDE	30	23	18	20	18	19	20	22	40	80	6.2	13	17	8.4	6.2	13	17	8.4	6.2	13	17	8.4	2.2
2,4'-DDD	<0.15	3.8	3	2.6	3.4	<0.2	4	3.2	9.5	9.1	1.5	3.4	4.3	2.6	1.5	3.4	4.3	2.6	1.5	3.4	4.3	2.6	0.9
4,4'-DDD	28	33	19	14	21	21	24	22	230	51	9.2	19	31	22	9.2	19	31	22	9.2	19	31	22	4.2
Dieldrin	60	30	26	29	26	33	33	29	98	110	12	28	32	19	12	28	32	19	12	28	32	19	1.7
Endrin	<0.15	<0.21	<0.2	<0.19	<0.2	<0.2	<0.2	<0.2	<0.18	<0.19	<0.22	<0.2	<0.19	<0.2	<0.22	<0.2	<0.19	<0.2	<0.22	<0.2	<0.19	<0.17	<0.2
Heptachlor	<0.15	0.7*	<0.2	<0.19	0.68*	0.68*	0.68*	0.65*	<0.18	<0.19	<0.22	0.66*	<0.19	<0.2	<0.22	0.66*	<0.19	<0.2	<0.22	0.66*	<0.19	<0.17	<0.2
Heptachlor Epoxide	<0.15	<0.21	<0.2	<0.19	<0.2	<0.2	<0.2	<0.2	<0.18	<0.19	<0.22	<0.2	<0.19	<0.2	<0.22	<0.2	<0.19	<0.2	<0.22	<0.2	<0.19	<0.17	<0.2
lindane	<0.11	<0.15	<0.14	<0.14	0.68*	<0.15	<0.15	<0.14	<0.13	<0.14	<0.16	<0.14	<0.14	<0.13	<0.16	<0.14	<0.14	<0.13	<0.16	<0.14	<0.14	<0.13	<0.15
Mirex	<0.076	<0.1	<0.099	<0.096	<0.1	<0.1	<0.1	<0.098	<0.088	<0.094	<0.11	<0.099	<0.094	<0.086	<0.11	<0.099	<0.094	<0.086	<0.11	<0.099	<0.086	<0.086	<0.1
trans-Nonachlor	10	5	4.1	4	3.4	3.9	5	5.1	10	6.8	1.5	0.14	6.4	0.13	1.5	0.14	6.4	0.13	1.5	0.14	6.4	0.13	<0.15
DDT ERM Quotient	0.05	0.06	0.02	0.02	0.02	0.02	0.03	0.04	0.13	0.09	0.01	0.02	0.03	0.03	0.01	0.02	0.03	0.03	0.01	0.02	0.03	0.03	0.01
Dieldrin Quotient	7.50	3.75	3.25	3.63	3.25	4.13	4.13	3.63	12.25	13.75	1.50	3.50	4.00	2.38	1.50	3.50	4.00	2.38	1.50	3.50	4.00	2.38	0.21

< = not detected at reported detection limit; \* = result between method reporting limit and reported detection limit

APPENDIX A  
SEDIMENT DATA

Station, Replicate	4N, REP1		5A, REP1		5C, REP1		5C, REP2		5C, REP3		5N, REP1		5S, REP1		6C, REP1		6N, REP1		6S, REP1		Reference (Paradise)
	Depth	1-2 ft	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	0-1 ft	1-2 ft	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	
PCBs and Aroclors (ng g <sup>-1</sup> dry weight)																					
PCB 8	1.5	<0.15	<0.14	<0.13	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	1.6	1.7	<0.15	<0.14	<0.13	<0.12	<0.12	<0.12	<0.12	<0.12	0.67*
PCB 18	2.7	2.4	2.2	5.2	3.9	3.4	6.3	1.8	3.2	4.1	3.2	4.1	11	0.92	1.8	0.77	0.77	1.8	0.77	0.77	<0.29
PCB 24	4.4	5.8	5.4	8.8	7.2	7.4	14	4.8	5.9	6.3	5.9	6.3	17	2	4.8	1.9	1.9	4.8	1.9	1.9	0.67*
PCB 44	7.4	5.1	4.1	8.2	5.3	7	8.8	5	7.7	14	7.7	14	8	2.6	5.1	2.3	2.3	5.1	2.3	2.3	0.67*
PCB 52	18	9.1	7.7	13	8.1	12	14	9.6	18	27	18	27	10	6.2	15	5.8	5.8	15	5.8	5.8	0.83
PCB 66	27	18	15	18	19	22	25	16	29	46	29	46	13	27	31	19	19	31	19	19	1.5
PCB 77	<0.12	<0.17	<0.16	<0.15	<0.16	<0.16	<0.16	<0.16	<0.14	<0.15	<0.14	<0.15	<0.17	<0.16	<0.15	<0.14	<0.14	<0.15	<0.14	<0.14	<0.16
PCB 101	38	30	24	27	30	35	36	27	48	64	48	64	16	41	49	29	29	49	29	29	1.7
PCB 105	17	12	9.8	11	12	12	15	10	17	27	17	27	5.5	9.1	9.8	7.4	7.4	9.8	7.4	7.4	0.69
PCB 118	32	27	21	24	23	28	29	22	35	64	35	64	12	23	27	15	15	27	15	15	1.9
PCB 126	<0.19	<0.26	<0.24	<0.24	<0.25	<0.25	<0.25	<0.24	<0.22	<0.23	<0.22	<0.23	<0.27	<0.24	<0.23	<0.21	<0.21	<0.23	<0.21	<0.21	<0.25
PCB 128	11	10	8.4	8.4	9.1	11	11	8.6	13	19	13	19	4.9	15	19	12	12	19	12	12	<0.11
PCB 138	97	70	71	69	85	96	100	69	150	180	150	180	42	170	210	130	130	210	130	130	2.8
PCB 153	78	58	48	47	57	63	71	58	100	120	100	120	30	120	160	95	95	160	95	95	2.6
PCB 170	42	38	32	29	41	47	54	38	84	85	84	85	20	130	180	110	110	180	110	110	0.78
PCB 180	61	56	46	42	59	67	77	55	120	120	120	120	29	190	250	150	150	250	150	150	1.6
PCB 187	37	32	27	26	34	37	42	32	59	56	59	56	18	79	99	62	62	99	62	62	1.3
PCB 195	7	6.5	5.8	4.7	7.2	7.8	8.4	7.4	13	13	13	13	3.4	22	30	17	17	30	17	17	0.67*
PCB 206	3.6	4	3.7	3.3	4	5	5.4	3.8	8.3	7	8.3	7	2.6	11	16	10	10	16	10	10	0.67*
PCB 209	0.78	1.7	1.8	1.5	2.1	2.4	5.4	1.7	42	2.7	42	2.7	1.3	2.3	2.7	3	3	2.7	3	3	0.67*
Total PCBs (NOAA 18)	480	380	330	350	410	460	520	370	750	860	750	860	240	850	1100	670	670	1100	670	670	18
Total Aroclor 1016	<100	<14	<13	<13	<14	<14	<14	<13	<100	<100	<100	<100	<14	<13	<12	<11	<11	<12	<11	<11	<13
Total Aroclor 1221	<100	<14	<13	<13	<14	<14	<14	<13	<100	<100	<100	<100	<14	<13	<12	<11	<11	<12	<11	<11	<13
Total Aroclor 1232	<100	<14	<13	<13	<14	<14	<14	<13	<100	<100	<100	<100	<14	<13	<12	<11	<11	<12	<11	<11	<13
Total Aroclor 1242	<100	<14	<13	<13	<14	<14	<14	<13	<100	<100	<100	<100	<14	<13	<12	<11	<11	<12	<11	<11	<13
Total Aroclor 1248	<100	<14	<13	<13	<14	<14	<14	<13	<100	<100	<100	<100	<14	<13	<12	<11	<11	<12	<11	<11	<13
Total Aroclor 1254	500*	420	340	350	360	440	440	360	580	890	580	890	170	300	350	200	200	350	200	200	67*
Total Aroclor 1260	500*	510	420	320	530	580	560	480	880	820	880	820	220	1400	1900	1100	1100	1900	1100	1100	67*

< = not detected at reported detection limit; \* = result between method reporting limit and reported detection limit

**APPENDIX B1**

**ERM AND BPTCP  
REFERENCE ENVELOPE 85%  
TOLERANCE LIMITS**

**APPENDIX B-1**  
**Sediment chemical toxicity effects ranges-median (ERM) and BPTCP**  
**San Francisco Bay Reference envelope 85% tolerance limits (adapted from Hunt et al., 1998)**

Chemical Name	Tolerance Limit p = 0.85	ERM (Long et al., 1995)
Aluminum	N/A	N/A
Antimony	N/A	N/A
Arsenic	15.3	70
Cadmium	0.33	9.6
Chormimum	112	370
Copper	68.1	270
Iron	N/A	N/A
Lead	43.2	218
Manganese	N/A	N/A
Mercury	0.43	0.7
Nickel	112	51.6
Silver	0.58	3.7
selemium	0.64	N/A
Tin	N/A	N/A
Zinc	158	410
Aldrin	N/A	N/A
Chloropyrifos	N/A	N/A
Total chlordane	1.1	6
Dacthal	N/A	N/A
Total DDT (Swartz)	7.0	100 ng-g <sup>-1</sup> OC
pp-Dichlorobenzophenone	N/A	N/A
Dieldrin	0.44	8
Endosulfan I	N/A	N/A
Endosulfan II	N/A	N/A
Endosulfan Sulfate	N/A	N/A
Endrin	N/A	45
Ethion	N/A	N/A
Alpha-HCH	N/A	N/A
Beta-HCH	N/A	N/A
Gamma-HCH (Lindane)	N/A	0.99 (PEL)
Delta-HCH	N/A	N/A
Heptachlor	N/A	N/A
Heptachlor Epoxide	N/A	N/A
Hexachlorobenzene	0.48	N/A
Methoxychlor	N/A	N/A
Mirex	N/A	N/A
Oxadiazon	N/A	N/A
Oxychlordane	N/A	N/A
Toxaphene	N/A	N/A
Tributyltin	N/A	N/A
Total PCB	14.8	180
Low MW PAHs	434	3160
High MW PAHs	3060	9600
Total PAHs	3390	44792
Total Organic Carbon	N/A	N/A
Mean ERM Quotent	N/A	N/A
Mean PEL Quotent	N/A	N/A

**APPENDIX B2**

**BPTCP CHEMICALS USED IN  
ERM CALCULATIONS**

**APPENDIX B2**  
**Chemicals Used in BPTCP ERM Quotients**

Category	Chemical Name
Total Chlordane	alpha-Chlordane
	cis-Nonachlor
	gamma-Chlordane
	Oxychlordane
	trans-Nonachlor

Dieldrin	Dieldrin
Endrin	Endrin

Total DDTs	2,4'-DDD
	2,4'-DDE
	2,4'-DDT
	4,4'-DDD
	4,4'-DDE
	4,4'-DDT

High Molecular Weight PAH	Benzo[a]anthracene
	Benzo[a]pyrene
	Benzo[b]fluoranthene
	Benzo[e]pyrene
	Benzo[g,h,i]perylene
	Benzo[k]fluoranthene
	Chrysene
	Dibenzo[a,h]anthracene
	Fluoranthene
	Indeno[1,2,3,-c,d]pyrene
	Perylene
Pyrene	

Low Molecular Weight PAH	1-Methylnaphthalene
	1-Methylphenanthrene
	2,3,5-Trimethylnaphthalene
	2,6-Dimethylnaphthalene
	2-Methylnaphthalene
	Acenaphthene
	Acenaphthylene
	Anthracene
	Biphenyl
	Fluorene
	Naphthalene
Phenanthrene	

Total PCBs	101 - 2,2',4,5,5'-Pentachlorobiphenyl (C15)
	105 - 2,3,3',4,4'-Pentachlorobiphenyl (C15)
	118 - 2,3',4,4',5-Pentachlorobiphenyl (C15)
	128 - 2,2',3,3',4,4'-Hexachlorobiphenyl (C16)
	138 - 2,2',3,4,4',5'-Hexachlorobiphenyl (C16)
	153 - 2,2',4,4',5,5'-Hexachlorobiphenyl (C16)
	170 - 2,2',3,3',4,4',5-Heptachlorobiphenyl (C17)
	180 - 2,2',3,4,4',5,5'-Heptachlorobiphenyl (C17)
	187 - 2,2',3,4',5,5',6-Heptachlorobiphenyl (C17)
	195 - 2,2',3,3',4,4',5,6-Octachlorobiphenyl
	206 - 2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl (C17)
	209 - 2,2',3,3',4,4',5,5',6,6'-Decachlorobiphenyl (C110)
	28 - 2,4,4'-Trichlorobiphenyl (C13)
	44 - 2,2',3,5'-Tetrachlorobiphenyl (C14)
	52 - 2,2',5,5'-Tetrachlorobiphenyl (C14)
	66 - 2,3',4,4'-Tetrachlorobiphenyl (C14)
	18 - 2,2',5-Trichlorobiphenyl (C13)
8 - 2,4'-Dichlorobiphenyl (C12)	

Metals	Antimony
	Arsenic
	Cadmium
	Chromium
	Copper
	Lead
	Mercury
	Silver
	Zinc

**APPENDIX B3**

**PERTINENT  
COMMUNICATIONS**

Edward\_Long@hazmat.noaa.gov (Edward Long) on 05/21/99 01:45:39 AM

To: Terence Parr/ADLittle@ADLittle  
cc:  
Subject: Re: PAHs, PCBs, Chlordane, ERMs

RFC822 message headers

Terry - my comments are below in UPPER CASE.

Ed Long

>Ed. ADL is doing some sediment contamination assessment work in some of  
>the  
>San Francisco creek channels (Islais, Mission, Yosemite).

AH, YES. SOME OF THE FINEST, VINTAGE SEDIMENTS THAT I HAVE ENCOUNTERED.

>Various  
>contaminants are found at elevated levels including lmwPAH, hmwPAH, PCBs  
>and  
>chlordane. We are trying to relate our findings to the ERM quotients  
>that are  
>utilized by the Regional Board in their Bay Protection Toxic Hot Spot  
>designations. They cite and utilize sediment ERMs from Long et al (1995)  
>as a  
>basis for indication of potential toxicity. I would like your advice and  
>feedback on the following.

>1) For the lmwPAH ERM of 3160 ppb and the hmw ERM  
>of 9600, are the compounds utilized to achieve those ERMS the ones that  
>are  
>listed on p. 93 of Long et al (1995), i.e. seven lmwPAH and six hmwPAHs  
>that  
>are listed.

YES. YOU ARE CORRECT. HOWEVER, PLEASE UNDERSTAND THAT THE "SUMMED"  
CONCENTRATIONS DO NOT NECESSARILY CORRESPOND TO ADDING UP THE SIX OR SEVEN  
ERLS OR ERMS FOR THE INDIVIDUAL SUBSTANCES. THEY WERE CALCULATED  
INDEPENDENTLY. SAME GOES THE THE TOTAL PAH VALUES.

>2) What are the PCBs that were included in the compilation of the  
>"Total PCBs" ERM of 180 ppb?. Any thoughts on evaluating PCBs and most  
>appropriate list relating to toxicity?  
THE PCB DATA LARGELY ARE FROM ANALYSES OF THE 18-20 CONGENERS QUANTIFIED  
BY NOAA. HOWEVER, THERE WERE SOME DATA FROM AROCLOR ANALYSES, BUT NOT  
MUCH. NOAA HAS DETERMINED EMPIRICALLY THAT BY SUMMING THE 18-20 CONGENERS  
AND MULTIPLYING BY A FACTOR OF 2.0, THAT THE TOTAL CLOSELY APPROXIMATES  
WHAT WOULD BE A "TOTAL PCB" CONCENTRATION FOR ALL ISOMERIC CONFIGURATIONS.

>3) Though Long et al. (1995) is cited  
>as a source for the chlordanes ERM of 6 ppb, it is not found there. It is  
>presented earlier, however, in Long and Morgan (1991). Since this seemed  
>to  
>have been dropped from your subsequent publications, what can you tell me  
>regarding the degree of confidence in the 6 ppb ERM. We find  
>concentrations  
>that are 10-15 times this level, yet there is good 10-day amphipod test  
>survival.

WE HAD SOME CHLORDANE DATA FROM FRESH WATER AND SALTWATER STUDIES IN THE  
EARLIER STUDY, WE HAD INSUFFICIENT SALTWATER DATA ALONE WHEN WE DID THE  
ANALYSES FOR THE 1995 PAPER. SO THE 1991 NUMBERS STAND AS OUR BEST  
ESTIMATE, BUT, WE LISTED CHLORDANE AS A SUBSTANCE FOR WHICH WE HAD  
RELATIVELY LOW CONFIDENCE IN THE PREDICTIVE ABILITY OF THE GUIDELINES.

>Any information and feedback much appreciated.  
I HAVE ADDITIONAL INFO. YOU MIGHT FIND USEFUL AT  
"[http://response.restoration.noaa.gov/living/sed\\_qual/SQGs.html](http://response.restoration.noaa.gov/living/sed_qual/SQGs.html)". Ed Long  
>  
>

**APPENDIX C**

**SUMMARY STATISTICS**

**APPENDIX C**  
**Summary Statistics**  
**Yosemite Creek**

Analyte	Units	n	Minimum	Maximum	Mean	Standard Deviation	Depth of Sample
SURVIVAL	Percent	5	51.11	72.78	64.28	8.34	Surface
TOC	Percent	19	1.25	2.69	1.97	0.41	Surface
GRAVEL	Percent	20	0.00	6.40	1.49	2.03	Surface
SAND	Percent	20	2.50	51.20	12.51	11.22	Surface
SILT	Percent	20	18.80	87.00	46.27	14.88	Surface
CLAY	Percent	20	10.00	55.30	39.73	11.28	Surface
SILTCLAY	Percent	20	42.40	97.50	86.00	12.91	Surface

Aluminum	ppm	20	23647.00	50725.00	37942.65	6731.14	Surface
Arsenic	ppm	20	8.20	11.50	9.55	0.91	Surface
Cadmium	ppm	20	0.33	1.37	0.71	0.26	Surface
Chormimum	ppm	20	103.00	168.00	127.65	15.75	Surface
Copper	ppm	20	79.00	236.00	114.45	35.34	Surface
Iron	ppm	20	30179.00	47306.00	39413.90	3778.85	Surface
Mercury	ppm	20	0.53	1.14	0.68	0.17	Surface
Lead	ppm	20	92.00	168.00	130.30	20.09	Surface
Nickel	ppm	20	78.00	140.00	94.05	15.14	Surface
Selenium	ppm	20	0.24	0.96	0.36	0.15	Surface
Silver	ppm	20	0.25	0.60	0.44	0.13	Surface
Zinc	ppm	20	186.00	289.00	224.75	26.03	Surface
Silver Quotient	none	20	0.07	0.16	0.12	0.04	Surface
Arsenic Quotient	none	20	0.12	0.16	0.14	0.01	Surface
Chormium Quotient	none	20	0.28	0.45	0.35	0.04	Surface
Cadmium Quotient	none	20	0.03	0.14	0.07	0.03	Surface
Copper Quotient	none	20	0.29	0.87	0.42	0.13	Surface
Lead Quotient	none	20	0.42	0.77	0.60	0.09	Surface
Mercury Quotient	none	20	0.76	1.63	0.97	0.25	Surface
Zinc Quotient	none	20	0.45	0.70	0.55	0.06	Surface

Naphthalene	ppb	20	25.00	120.00	59.05	21.12	Surface
C1-Naphthalenes	ppb	20	17.00	160.00	60.80	31.88	Surface
C2-Naphthalenes	ppb	20	28.00	190.00	79.25	34.39	Surface
C3-Naphthalenes	ppb	20	37.00	100.00	60.80	17.38	Surface
C4-Naphthalenes	ppb	20	32.00	91.00	54.20	14.86	Surface
Acenaphthylene	ppb	20	26.00	120.00	57.90	28.66	Surface
Acenaphthene	ppb	20	7.00	31.00	16.65	6.77	Surface
Biphenyl	ppb	20	7.50	35.00	18.58	6.77	Surface
Dibenzofuran	ppb	20	8.50	24.00	13.07	3.82	Surface
Fluorene	ppb	20	15.00	68.00	28.75	13.40	Surface
C1-Fluorenes	ppb	20	15.00	44.00	25.05	7.02	Surface
C2-Fluorenes	ppb	20	19.00	47.00	29.65	6.79	Surface
C3-Fluorenes	ppb	20	40.00	85.00	58.15	12.89	Surface
Anthracene	ppb	20	45.00	390.00	118.80	75.67	Surface
Phenanthrene	ppb	20	95.00	720.00	252.75	153.41	Surface
C1-Phenanthrenes/anthracenes	ppb	20	82.00	300.00	161.95	65.12	Surface
C2-Phenanthrenes/anthracenes	ppb	20	89.00	230.00	131.10	43.30	Surface
C3-Phenanthrenes/anthracenes	ppb	20	60.00	170.00	98.55	29.23	Surface
C4-Phenanthrenes/anthracenes	ppb	20	91.00	380.00	193.05	74.56	Surface
Dibenzothiophene	ppb	20	11.00	37.00	19.75	7.80	Surface
C1-Dibenzothiophenes	ppb	20	11.00	34.00	19.70	6.27	Surface
C2-Dibenzothiophenes	ppb	20	23.00	78.00	42.90	15.44	Surface
C3-Dibenzothiophenes	ppb	20	26.00	95.00	46.55	18.75	Surface
Fluoranthene	ppb	20	270.00	1300.00	519.50	268.51	Surface
Pyrene	ppb	20	360.00	1500.00	672.00	311.04	Surface

**APPENDIX C**  
**Summary Statistics**  
**Yosemite Creek**

Analyte	Units	n	Minimum	Maximum	Mean	Standard Deviation	Depth of Sample
C1-Fluoranthenes/pyrenes	ppb	20	140.00	590.00	307.00	132.71	Surface
C2-Fluoranthenes/pyrenes	ppb	20	100.00	360.00	197.50	65.04	Surface
C3-Fluoranthenes/pyrenes	ppb	20	75.00	190.00	118.90	33.20	Surface
Benzo[a]anthracene	ppb	20	130.00	690.00	320.50	170.15	Surface
Chrysene	ppb	20	160.00	920.00	400.50	215.10	Surface
C1-Chrysenes	ppb	20	88.00	370.00	185.75	76.71	Surface
C2-Chrysenes	ppb	20	73.00	260.00	144.55	49.25	Surface
C3-Chrysenes	ppb	20	69.00	210.00	124.45	38.15	Surface
C4-Chrysenes	ppb	20	60.00	170.00	104.45	29.89	Surface
Benzo[b]fluoranthene	ppb	20	380.00	1300.00	662.00	253.89	Surface
Benzo[k]fluoranthene	ppb	20	97.00	420.00	203.85	94.51	Surface
Benzo[e]pyrene	ppb	20	220.00	780.00	396.50	152.91	Surface
Benzo[a]pyrene	ppb	20	280.00	1000.00	521.00	214.28	Surface
Perylene	ppb	20	100.00	310.00	169.50	53.65	Surface
Indeno[1,2,3,-c,d]pyrene	ppb	20	220.00	660.00	370.50	119.45	Surface
Dibenzo[a,h]anthracene	ppb	20	28.00	100.00	53.60	20.40	Surface
Benzo[g,h,i]perylene	ppb	20	200.00	720.00	384.50	131.93	Surface
LONG AND MORGAN PAH	ppb	20	1076.90	3590.00	1982.66	783.83	Surface
ADL TOTAL PAH	ppb	20	4236.90	14032.60	7640.74	2827.27	Surface
LOW PAHS QUOTIENT	none	20	0.08	0.42	0.19	0.09	Surface
HIGH PAHS QUOTIENT	none	20	0.13	0.52	0.26	0.12	Surface
C10B-Phenyl decanes	ppb	20	0.24	38.00	7.97	12.70	Surface
C11B-Phenyl undecanes	ppb	20	0.55	42.00	20.86	12.45	Surface
C12B-Phenyl dodecanes	ppb	20	0.26	32.00	4.82	9.96	Surface
C13B-Phenyl tridecanes	ppb	20	34.00	110.00	65.80	23.12	Surface
C14B-Phenyl tetradecanes	ppb	20	0.24	130.00	37.76	40.45	Surface
n-Nonane	ppb	20	0.14	0.38	0.29	0.08	Surface
n-Decane	ppb	20	0.01	0.05	0.02	0.01	Surface
n-Undecane	ppb	20	0.02	0.04	0.03	0.01	Surface
n-Dodecane	ppb	20	0.02	0.05	0.03	0.01	Surface
n-Tridecane	ppb	20	0.02	0.06	0.04	0.01	Surface
Isoprenoid RRT 1380	ppb	20	0.03	0.07	0.05	0.02	Surface
n-Tetradecane	ppb	20	0.03	0.09	0.07	0.02	Surface
Isoprenoid RRT 1470	ppb	20	0.01	0.07	0.04	0.01	Surface
n-Pentadecane	ppb	20	0.02	0.04	0.03	0.01	Surface
n-Hexadecane	ppb	20	0.02	0.06	0.04	0.01	Surface
Isoprenoid RRT 1650	ppb	20	0.02	0.05	0.03	0.01	Surface
n-Heptadecane	ppb	20	0.12	7.20	1.14	1.59	Surface
Pristane	ppb	20	0.03	0.08	0.05	0.01	Surface
n-Octadecane	ppb	20	0.02	0.06	0.04	0.01	Surface
Phytane	ppb	20	0.04	0.12	0.07	0.02	Surface
n-Nonadecane	ppb	20	0.01	0.08	0.05	0.02	Surface
n-Eicosane	ppb	20	0.01	0.15	0.06	0.06	Surface
n-Heneicosane	ppb	20	0.01	0.78	0.08	0.17	Surface
n-Docosane	ppb	20	0.06	0.44	0.20	0.11	Surface
n-Tricosane	ppb	20	0.12	0.28	0.19	0.04	Surface
n-Tetracosane	ppb	20	0.01	0.27	0.05	0.08	Surface
n-Pentacosane	ppb	20	0.03	0.46	0.16	0.10	Surface
n-Hexacosane	ppb	20	0.01	0.62	0.12	0.14	Surface
n-Heptacosane	ppb	20	0.02	1.20	0.38	0.23	Surface
n-Octacosane	ppb	20	0.01	1.50	0.43	0.46	Surface
n-Nonacosane	ppb	20	0.35	2.30	0.99	0.48	Surface
n-Triacontane	ppb	20	0.02	1.80	0.22	0.39	Surface
n-Hentriacontane	ppb	20	0.51	3.00	1.35	0.61	Surface

**APPENDIX C**  
**Summary Statistics**  
**Yosemite Creek**

Analyte	Units	n	Minimum	Maximum	Mean	Standard Deviation	Depth of Sample
n-Dotriacontane	ppb	20	0.02	1.90	0.29	0.41	Surface
n-Tritriacontane	ppb	20	0.22	2.40	0.67	0.49	Surface
n-Tetracontane	ppb	20	0.02	1.70	0.27	0.39	Surface
n-Pentatriacontane	ppb	20	0.02	1.70	0.23	0.37	Surface
n-Hexatriacontane	ppb	20	0.03	1.20	0.23	0.25	Surface
n-Heptatriacontane	ppb	20	0.02	1.30	0.22	0.27	Surface
n-Octatriacontane	ppb	20	0.02	1.00	0.23	0.23	Surface
n-Nonatriacontane	ppb	20	0.01	0.45	0.11	0.10	Surface
n-Tetracontane	ppb	20	0.01	0.38	0.11	0.08	Surface
Total Resolved Hydrocarbons	ppb	20	31.00	96.00	59.80	15.46	Surface
Total Petroleum Hydrocarbons	ppb	20	320.00	1400.00	711.00	255.24	Surface
TPH >C8-C10	ppb	20	1.80	4.40	2.61	0.67	Surface
TPH >C10-C12	ppb	20	0.99	5.50	2.15	1.00	Surface
TPH >C12-C16	ppb	20	4.40	20.00	10.56	4.13	Surface
TPH >C16-C21	ppb	20	30.00	140.00	66.35	27.60	Surface
TPH >C21-C25	ppb	20	48.00	250.00	117.90	47.64	Surface
TPH >C25-C30	ppb	20	87.00	420.00	207.85	77.81	Surface
TPH >C30-C35	ppb	20	75.00	330.00	169.65	58.24	Surface
TPH >C35 +	ppb	20	69.00	260.00	138.60	45.92	Surface

Heptachlor	ppb	20	0.09	1.10	0.27	0.24	Surface
Aldrin	ppb	20	0.09	0.40	0.12	0.07	Surface
alpha-Chlordane	ppb	20	1.30	25.00	7.64	5.34	Surface
gamma-Chlordane	ppb	20	2.20	39.00	14.64	9.01	Surface
cis-Nonachlor	ppb	20	0.09	5.60	3.15	1.31	Surface
2,4'-DDT	ppb	20	0.14	0.20	0.17	0.01	Surface
4,4'-DDT	ppb	20	0.22	36.00	5.13	8.76	Surface
2,4'-DDE	ppb	20	0.14	26.00	1.46	5.78	Surface
4,4'-DDE	ppb	20	6.20	80.00	27.63	18.13	Surface
2,4'-DDD	ppb	20	0.10	5.90	3.26	1.44	Surface
4,4'-DDD	ppb	20	9.20	33.00	23.26	6.00	Surface
TOTAL DDT	ppb	20	18.36	142.47	60.92	27.49	Surface
Dieldrin	ppb	20	12.00	110.00	37.00	20.07	Surface
Endrin	ppb	20	0.09	0.12	0.10	0.01	Surface
Heptachlor Epoxide	ppb	20	0.09	0.12	0.10	0.01	Surface
lindane	ppb	20	0.06	0.38	0.09	0.07	Surface
Mirex	ppb	20	0.04	0.06	0.05	0.00	Surface
trans-Nonachlor	ppb	20	0.06	10.00	4.83	2.49	Surface
TOTAL CHLORDANE	ppb	20	7.06	78.20	30.24	16.78	Surface
CHLORDANE QUOTIENT	none	20	1.18	13.03	5.04	2.80	Surface
DDT QUOTIENT	none	19	0.01	0.06	0.03	0.01	Surface
DIELDRIN QUOTIENT	none	20	1.50	13.75	4.63	2.51	Surface

**APPENDIX C**  
**Summary Statistics**  
**Yosemite Creek**

Analyte	Units	n	Minimum	Maximum	Mean	Standard Deviation	Depth of Sample
8 - 2,4'-Dichlorobiphenyl (C12)	ppb	20	0.06	1.70	0.22	0.47	Surface
18 - 2,2',5'-Trichlorobiphenyl (C13)	ppb	20	0.77	11.00	2.83	2.38	Surface
28 - 2,4,4'-Trichlorobiphenyl (C13)	ppb	20	1.90	17.00	6.28	3.61	Surface
44 - 2,2',3,5'-Tetrachlorobiphenyl (C14)	ppb	20	2.30	19.00	6.28	3.54	Surface
52 - 2,2',5,5'-Tetrachlorobiphenyl (C14)	ppb	20	5.80	36.00	11.62	6.53	Surface
66 - 2,3',4,4'-Tetrachlorobiphenyl (C14)	ppb	20	0.06	52.00	21.40	9.64	Surface
77 - 3,3',4,4'-Tetrachlorobiphenyl (C14)	ppb	20	0.07	0.09	0.08	0.01	Surface
101 - 2,2',4,5,5'-Pentachlorobiphenyl (C15)	ppb	20	16.00	83.00	37.10	14.20	Surface
105 - 2,3,3',4,4'-Pentachlorobiphenyl (C15)	ppb	20	5.50	38.00	14.63	7.66	Surface
118 - 2,3',4,4',5'-Pentachlorobiphenyl (C15)	ppb	20	12.00	95.00	32.30	17.82	Surface
126 - 3,3',4,4',5'-Pentachlorobiphenyl (C15)	ppb	20	0.10	0.15	0.13	0.01	Surface
128 - 2,2',3,3',4,4'-Hexachlorobiphenyl (C16)	ppb	20	4.90	25.00	12.40	4.69	Surface
138 - 2,2',3,4,4',5'-Hexachlorobiphenyl (C16)	ppb	20	42.00	210.00	102.50	39.92	Surface
153 - 2,2',4,4',5,5'-Hexachlorobiphenyl (C16)	ppb	20	30.00	160.00	72.00	29.15	Surface
170 - 2,2',3,3',4,4',5'-Heptachlorobiphenyl (C17)	ppb	20	20.00	180.00	56.15	39.06	Surface
180 - 2,2',3,4,4',5,5'-Heptachlorobiphenyl (C17)	ppb	20	29.00	250.00	78.65	54.73	Surface
187 - 2,2',3,4',5,5',6'-Heptachlorobiphenyl (C17)	ppb	20	18.00	99.00	41.00	19.12	Surface
195 - 2,2',3,3',4,4',5,6'-Octachlorobiphenyl	ppb	20	3.40	30.00	9.78	6.33	Surface
206 - 2,2',3,3',4,4',5,5',6'-Nonachlorobiphenyl (C17)	ppb	20	2.60	16.00	5.76	3.31	Surface
209 - 2,2',3,3',4,4',5,5',6,6'-Decachlorobiphenyl (C110)	ppb	20	1.30	5.40	2.55	1.00	Surface
Total PCB Congeners	ppb	20	240.00	1100.00	512.00	206.97	Surface
BPTCP PCBs	ppb	20	243.78	1110.26	513.45	208.49	Surface
Total Aroclor 1016	ppb	20	5.50	8.00	6.83	0.57	Surface
Total Aroclor 1221	ppb	20	5.50	8.00	6.83	0.57	Surface
Total Aroclor 1232	ppb	20	5.50	8.00	6.83	0.57	Surface
Total Aroclor 1242	ppb	20	5.50	8.00	6.83	0.57	Surface
Total Aroclor 1248	ppb	20	5.50	8.00	6.83	0.57	Surface
Total Aroclor 1260	ppb	20	220.00	1900.00	648.50	394.40	Surface
Total Aroclor 1254	ppb	20	170.00	900.00	434.50	167.97	Surface
PCB QUOTIENT	none	20	1.35	6.17	2.85	1.16	Surface

**APPENDIX C**  
**Summary Statistics**  
**Yosemite Creek**

Analyte	Units	n	Minimum	Maximum	Mean	Standard Deviation	Depth of Sample
TOC	Percent	5	1.83	3.94	2.48	0.84	0-1 m
GRAVEL	Percent	5	0.00	11.10	3.06	4.57	0-1 m
SAND	Percent	5	6.40	32.90	16.62	9.86	0-1 m
SILT	Percent	5	37.00	79.00	52.72	17.45	0-1 m
CLAY	Percent	5	14.60	42.80	27.60	12.51	0-1 m
SILTCLAY	Percent	5	66.20	93.60	80.32	10.02	0-1 m

Aluminum	ppm	5	29874.00	50244.00	41349.80	8937.39	0-1 m
Arsenic	ppm	5	8.80	11.70	10.16	1.09	0-1 m
Cadmium	ppm	5	0.84	8.63	2.66	3.36	0-1 m
Chormimum	ppm	5	125.00	368.00	194.80	98.64	0-1 m
Copper	ppm	5	87.00	146.00	106.60	23.43	0-1 m
Iron	ppm	5	30682.00	44307.00	39857.20	5708.77	0-1 m
Mercury	ppm	5	0.01	1.49	0.66	0.57	0-1 m
Lead	ppm	5	119.00	811.00	293.40	293.36	0-1 m
Nickel	ppm	5	74.00	108.00	90.60	12.48	0-1 m
Selenium	ppm	5	0.29	1.52	0.64	0.50	0-1 m
Silver	ppm	5	0.15	1.20	0.51	0.44	0-1 m
Zinc	ppm	5	221.00	830.00	371.40	258.83	0-1 m
Silver Quotient	none	5	0.04	0.32	0.14	0.12	0-1 m
Arsenic Quotient	none	5	0.13	0.17	0.15	0.02	0-1 m
Chormium Quotient	none	5	0.34	0.99	0.53	0.27	0-1 m
Cadmium Quotient	none	5	0.09	0.90	0.28	0.35	0-1 m
Copper Quotient	none	5	0.32	0.54	0.39	0.09	0-1 m
Lead Quotient	none	5	0.55	3.72	1.35	1.35	0-1 m
Mercury Quotient	none	5	0.01	2.13	0.94	0.82	0-1 m
Zinc Quotient	none	5	0.54	2.02	0.91	0.63	0-1 m

Naphthalene	ppb	5	38.00	560.00	169.80	222.76	0-1 m
C1-Naphthalenes	ppb	5	47.00	420.00	161.60	163.71	0-1 m
C2-Naphthalenes	ppb	5	78.00	710.00	245.00	269.31	0-1 m
C3-Naphthalenes	ppb	5	50.00	490.00	185.60	184.25	0-1 m
C4-Naphthalenes	ppb	5	48.00	650.00	195.80	257.95	0-1 m
Acenaphthylene	ppb	5	30.00	350.00	107.60	136.16	0-1 m
Acenaphthene	ppb	5	14.00	110.00	38.20	40.49	0-1 m
Biphenyl	ppb	5	14.00	120.00	40.60	45.51	0-1 m
Dibenzofuran	ppb	5	8.90	64.00	22.24	23.57	0-1 m
Fluorene	ppb	5	20.00	200.00	61.40	77.74	0-1 m
C1-Fluorenes	ppb	5	24.00	240.00	75.80	92.69	0-1 m
C2-Fluorenes	ppb	5	27.00	320.00	97.60	125.80	0-1 m
C3-Fluorenes	ppb	5	50.00	1100.00	283.40	457.91	0-1 m
Anthracene	ppb	5	72.00	1000.00	281.20	402.89	0-1 m
Phenanthrene	ppb	5	180.00	740.00	298.00	247.22	0-1 m
C1-Phenanthrenes/anthracenes	ppb	5	140.00	1000.00	340.00	371.21	0-1 m
C2-Phenanthrenes/anthracenes	ppb	5	110.00	1500.00	430.00	600.96	0-1 m
C3-Phenanthrenes/anthracenes	ppb	5	89.00	2200.00	555.80	922.02	0-1 m
C4-Phenanthrenes/anthracenes	ppb	5	120.00	2900.00	722.00	1219.64	0-1 m
Dibenzothiophene	ppb	5	16.00	95.00	34.20	34.15	0-1 m
C1-Dibenzothiophenes	ppb	5	20.00	170.00	55.80	64.68	0-1 m
C2-Dibenzothiophenes	ppb	5	38.00	650.00	176.80	266.22	0-1 m
C3-Dibenzothiophenes	ppb	5	36.00	1100.00	272.60	464.04	0-1 m
Fluoranthene	ppb	5	270.00	2600.00	796.00	1009.49	0-1 m
Pyrene	ppb	5	420.00	7100.00	1878.00	2923.02	0-1 m
C1-Fluoranthenes/pyrenes	ppb	5	220.00	4700.00	1204.00	1957.94	0-1 m

**APPENDIX C**  
**Summary Statistics**  
**Yosemite Creek**

Analyte	Units	n	Minimum	Maximum	Mean	Standard Deviation	Depth of Sample
C2-Fluoranthenes/pyrenes	ppb	5	140.00	2700.00	728.00	1108.32	0-1 m
C3-Fluoranthenes/pyrenes	ppb	5	94.00	1700.00	496.80	684.16	0-1 m
Benzo[a]anthracene	ppb	5	170.00	1800.00	544.00	703.01	0-1 m
Chrysene	ppb	5	180.00	1600.00	522.00	604.09	0-1 m
C1-Chrysenes	ppb	5	120.00	1600.00	458.00	640.21	0-1 m
C2-Chrysenes	ppb	5	110.00	1200.00	380.00	465.13	0-1 m
C3-Chrysenes	ppb	5	95.00	860.00	311.00	318.83	0-1 m
C4-Chrysenes	ppb	5	80.00	780.00	276.00	290.74	0-1 m
Benzo[b]fluoranthene	ppb	5	410.00	2500.00	902.00	895.50	0-1 m
Benzo[k]fluoranthene	ppb	5	100.00	890.00	304.00	329.36	0-1 m
Benzo[e]pyrene	ppb	5	230.00	2000.00	654.00	755.50	0-1 m
Benzo[a]pyrene	ppb	5	310.00	2800.00	894.00	1068.10	0-1 m
Perylene	ppb	5	100.00	700.00	252.00	251.63	0-1 m
Indeno[1,2,3,-c,d]pyrene	ppb	5	240.00	1500.00	534.00	540.91	0-1 m
Dibenzo[a,h]anthracene	ppb	5	28.00	280.00	88.40	107.42	0-1 m
Benzo[g,h,i]perylene	ppb	5	210.00	1700.00	566.00	635.95	0-1 m
LONG AND MORGAN PAH	ppb	5	1224.90	13484.00	4094.84	5267.55	0-1 m
ADL TOTAL PAH	ppb	5	5057.48	55786.50	16869.87	21855.29	0-1 m
LOW PAHS QUOTIENT	none	5	0.14	1.07	0.35	0.40	0-1 m
HIGH PAHS QUOTIENT	none	5	0.14	1.69	0.49	0.67	0-1 m
C10B-Phenyl decanes	ppb	5	0.29	120.00	41.36	46.20	0-1 m
C11B-Phenyl undecanes	ppb	5	14.00	120.00	45.30	43.18	0-1 m
C12B-Phenyl dodecanes	ppb	5	0.29	17.50	4.17	7.48	0-1 m
C13B-Phenyl tridecanes	ppb	5	17.50	180.00	74.10	62.05	0-1 m
C14B-Phenyl tetradecanes	ppb	5	17.50	200.00	65.70	75.74	0-1 m
n-Nonane	ppb	5	0.15	5.00	1.35	2.08	0-1 m
n-Decane	ppb	5	0.02	0.49	0.14	0.20	0-1 m
n-Undecane	ppb	5	0.02	0.60	0.16	0.25	0-1 m
n-Dodecane	ppb	5	0.02	0.60	0.16	0.25	0-1 m
n-Tridecane	ppb	5	0.02	0.80	0.22	0.33	0-1 m
Isoprenoid RRT 1380	ppb	5	0.03	0.95	0.26	0.39	0-1 m
n-Tetradecane	ppb	5	0.04	1.25	0.34	0.52	0-1 m
Isoprenoid RRT 1470	ppb	5	0.03	0.48	0.13	0.19	0-1 m
n-Pentadecane	ppb	5	0.01	0.50	0.14	0.21	0-1 m
n-Hexadecane	ppb	5	0.02	0.26	0.09	0.10	0-1 m
Isoprenoid RRT 1650	ppb	5	0.02	0.60	0.16	0.25	0-1 m
n-Heptadecane	ppb	5	0.46	9.90	2.77	4.02	0-1 m
Pristane	ppb	5	0.02	3.30	0.72	1.44	0-1 m
n-Octadecane	ppb	5	0.02	0.70	0.20	0.29	0-1 m
Phytane	ppb	5	0.05	2.70	0.63	1.16	0-1 m
n-Nonadecane	ppb	5	0.01	0.34	0.10	0.14	0-1 m
n-Eicosane	ppb	5	0.01	0.22	0.08	0.10	0-1 m
n-Heneicosane	ppb	5	0.02	5.40	1.76	2.09	0-1 m
n-Docosane	ppb	5	0.01	0.40	0.20	0.16	0-1 m
n-Tricosane	ppb	5	0.01	1.50	0.38	0.63	0-1 m
n-Tetracosane	ppb	5	0.01	1.40	0.31	0.61	0-1 m
n-Pentacosane	ppb	5	0.02	0.60	0.16	0.25	0-1 m
n-Hexacosane	ppb	5	0.01	0.32	0.09	0.13	0-1 m
n-Heptacosane	ppb	5	0.07	0.33	0.23	0.10	0-1 m
n-Octacosane	ppb	5	0.01	0.79	0.36	0.35	0-1 m
n-Nonacosane	ppb	5	0.43	2.30	0.90	0.80	0-1 m
n-Triacontane	ppb	5	0.02	0.80	0.22	0.33	0-1 m
n-Hentriacontane	ppb	5	0.67	10.00	2.97	3.98	0-1 m
n-Dotriacontane	ppb	5	0.01	3.40	0.85	1.45	0-1 m

**APPENDIX C**  
**Summary Statistics**  
**Yosemite Creek**

Analyte	Units	n	Minimum	Maximum	Mean	Standard Deviation	Depth of Sample
n-Tritriacontane	ppb	5	0.09	0.62	0.39	0.22	0-1 m
n-Tetracontane	ppb	5	0.01	0.34	0.17	0.15	0-1 m
n-Pentatriacontane	ppb	5	0.01	0.66	0.21	0.28	0-1 m
n-Hexatriacontane	ppb	5	0.01	0.43	0.15	0.17	0-1 m
n-Heptatriacontane	ppb	5	0.01	0.39	0.14	0.14	0-1 m
n-Octatriacontane	ppb	5	0.01	0.35	0.15	0.13	0-1 m
n-Nonatriacontane	ppb	5	0.01	0.34	0.09	0.14	0-1 m
n-Tetracontane	ppb	5	0.01	0.35	0.09	0.15	0-1 m
Total Resolved Hydrocarbons	ppb	5	49.00	640.00	178.60	258.76	0-1 m
Total Petroleum Hydrocarbons	ppb	5	540.00	7400.00	2190.00	2929.47	0-1 m
TPH >C8-C10	ppb	5	1.20	5.50	2.72	1.84	0-1 m
TPH >C10-C12	ppb	5	1.10	94.00	20.90	40.88	0-1 m
TPH >C12-C16	ppb	5	8.00	250.00	62.00	105.42	0-1 m
TPH >C16-C21	ppb	5	49.00	1200.00	309.60	499.19	0-1 m
TPH >C21-C25	ppb	5	91.00	1400.00	402.20	560.90	0-1 m
TPH >C25-C30	ppb	5	160.00	1900.00	588.00	739.17	0-1 m
TPH >C30-C35	ppb	5	130.00	1400.00	446.00	537.80	0-1 m
TPH >C35 +	ppb	5	100.00	1100.00	358.00	420.14	0-1 m

Heptachlor	ppb	5	0.09	0.16	0.11	0.03	0-1 m
Aldrin	ppb	5	0.09	0.17	0.12	0.03	0-1 m
alpha-Chlordane	ppb	5	5.40	52.00	18.12	19.21	0-1 m
gamma-Chlordane	ppb	5	10.00	110.00	37.40	41.06	0-1 m
cis-Nonachlor	ppb	5	2.00	15.00	5.62	5.31	0-1 m
2,4'-DDT	ppb	5	0.14	0.26	0.18	0.05	0-1 m
4,4'-DDT	ppb	5	0.25	3.60	1.54	1.43	0-1 m
2,4'-DDE	ppb	5	0.14	0.26	0.18	0.05	0-1 m
4,4'-DDE	ppb	5	21.00	670.00	161.80	284.23	0-1 m
2,4'-DDD	ppb	5	3.00	280.00	60.30	122.84	0-1 m
4,4'-DDD	ppb	5	16.00	480.00	154.40	203.40	0-1 m
TOTAL DDT	ppb	5	42.42	1430.90	378.41	596.40	0-1 m
Dieldrin	ppb	5	26.00	370.00	119.20	142.69	0-1 m
Endrin	ppb	5	0.09	0.16	0.11	0.03	0-1 m
Heptachlor Epoxide	ppb	5	0.09	0.16	0.11	0.03	0-1 m
lindane	ppb	5	0.06	0.12	0.08	0.02	0-1 m
Mirex	ppb	5	0.04	0.08	0.06	0.01	0-1 m
trans-Nonachlor	ppb	5	4.60	31.00	11.48	11.11	0-1 m
TOTAL CHLORDANE	ppb	5	22.00	208.00	72.62	76.65	0-1 m
CHLORDANE QUOTIENT	none	5	3.67	34.67	12.10	12.78	0-1 m
DDT QUOTIENT	none	5	0.02	0.36	0.11	0.15	0-1 m
DIELDRIN QUOTIENT	none	5	3.25	46.25	14.90	17.84	0-1 m

**APPENDIX C**  
**Summary Statistics**  
**Yosemite Creek**

Analyte	Units	n	Minimum	Maximum	Mean	Standard Deviation	Depth of Sample
8 - 2,4'-Dichlorobiphenyl (C12)	ppb	5	0.08	5.50	2.16	2.02	0-1 m
18 - 2,2',5'-Trichlorobiphenyl (C13)	ppb	5	1.30	7.20	3.16	2.36	0-1 m
28 - 2,4,4'-Trichlorobiphenyl (C13)	ppb	5	3.80	9.20	5.64	2.13	0-1 m
44 - 2,2',3,5'-Tetrachlorobiphenyl (C14)	ppb	5	5.10	67.00	18.48	27.14	0-1 m
52 - 2,2',5,5'-Tetrachlorobiphenyl (C14)	ppb	5	11.00	77.00	26.60	28.31	0-1 m
66 - 2,3',4,4'-Tetrachlorobiphenyl (C14)	ppb	5	18.00	230.00	64.60	92.55	0-1 m
77 - 3,3',4,4'-Tetrachlorobiphenyl (C14)	ppb	5	0.07	0.13	0.09	0.02	0-1 m
101 - 2,2',4,5,5'-Pentachlorobiphenyl (C15)	ppb	5	28.00	130.00	57.40	41.25	0-1 m
105 - 2,3,3',4,4'-Pentachlorobiphenyl (C15)	ppb	5	11.00	140.00	40.00	55.97	0-1 m
118 - 2,3',4,4',5'-Pentachlorobiphenyl (C15)	ppb	5	25.00	80.00	42.80	21.49	0-1 m
126 - 3,3',4,4',5'-Pentachlorobiphenyl (C15)	ppb	5	0.11	0.19	0.14	0.03	0-1 m
128 - 2,2',3,3',4,4'-Hexachlorobiphenyl (C16)	ppb	5	9.00	89.00	27.60	34.39	0-1 m
138 - 2,2',3,4,4',5'-Hexachlorobiphenyl (C16)	ppb	5	71.00	280.00	142.20	82.06	0-1 m
153 - 2,2',4,4',5,5'-Hexachlorobiphenyl (C16)	ppb	5	51.00	350.00	127.20	125.82	0-1 m
170 - 2,2',3,3',4,4',5'-Heptachlorobiphenyl (C17)	ppb	5	35.00	280.00	97.80	103.57	0-1 m
180 - 2,2',3,4,4',5,5'-Heptachlorobiphenyl (C17)	ppb	5	48.00	390.00	135.80	144.84	0-1 m
187 - 2,2',3,4',5,5',6'-Heptachlorobiphenyl (C17)	ppb	5	28.00	160.00	63.60	55.14	0-1 m
195 - 2,2',3,3',4,4',5,6'-Octachlorobiphenyl	ppb	5	5.10	36.00	13.82	12.83	0-1 m
206 - 2,2',3,3',4,4',5,5',6'-Nonachlorobiphenyl (C17)	ppb	5	3.90	18.00	8.06	5.82	0-1 m
209 - 2,2',3,3',4,4',5,5',6,6'-Decachlorobiphenyl (C110)	ppb	5	1.70	42.00	11.32	17.31	0-1 m
Total PCB Congeners	ppb	5	360.00	2400.00	896.00	852.78	0-1 m
BPTCP PCBs	ppb	5	358.10	2356.50	888.24	833.52	0-1 m
Total Aroclor 1016	ppb	5	7.00	50.00	33.50	22.63	0-1 m
Total Aroclor 1221	ppb	5	7.00	50.00	33.50	22.63	0-1 m
Total Aroclor 1232	ppb	5	7.00	50.00	33.50	22.63	0-1 m
Total Aroclor 1242	ppb	5	7.00	50.00	33.50	22.63	0-1 m
Total Aroclor 1248	ppb	5	7.00	50.00	33.50	22.63	0-1 m
Total Aroclor 1260	ppb	5	350.00	10000.00	2436.00	4233.13	0-1 m
Total Aroclor 1254	ppb	5	350.00	14000.00	3202.00	6036.97	0-1 m
PCB QUOTIENT	none	5	1.99	13.09	4.93	4.63	0-1 m

**APPENDIX C**  
**Summary Statistics**  
**Yosemite Creek**

Analyte	Units	n	Minimum	Maximum	Mean	Standard Deviation	Depth of Sample
TOC	Percent	5	1.30	2.56	1.83	0.47	1-2 m
GRAVEL	Percent	5	3.40	17.20	7.58	5.94	1-2 m
SAND	Percent	5	8.30	70.10	47.22	23.49	1-2 m
SILT	Percent	5	9.20	45.00	29.08	13.23	1-2 m
CLAY	Percent	5	5.70	43.10	16.12	15.39	1-2 m
SILTCLAY	Percent	5	20.40	88.10	45.20	26.08	1-2 m

Aluminum	ppm	5	9499.00	33376.00	22009.20	11171.79	1-2 m
Arsenic	ppm	5	7.00	11.70	9.82	2.14	1-2 m
Cadmium	ppm	5	0.46	8.00	3.09	2.89	1-2 m
Chormimum	ppm	5	51.00	234.00	139.40	67.55	1-2 m
Copper	ppm	5	57.00	445.00	153.60	164.67	1-2 m
Iron	ppm	5	15918.00	36311.00	27920.60	9132.86	1-2 m
Mercury	ppm	5	0.12	0.98	0.55	0.31	1-2 m
Lead	ppm	5	38.00	636.00	266.40	223.81	1-2 m
Nickel	ppm	5	29.00	76.00	58.00	18.85	1-2 m
Selenium	ppm	5	0.16	1.55	0.62	0.54	1-2 m
Silver	ppm	5	0.05	2.00	0.65	0.83	1-2 m
Zinc	ppm	5	157.00	678.00	333.80	201.51	1-2 m
Silver Quotient	none	5	0.01	0.54	0.18	0.22	1-2 m
Arsenic Quotient	none	5	0.10	0.17	0.14	0.03	1-2 m
Chormium Quotient	none	5	0.14	0.63	0.38	0.18	1-2 m
Cadmium Quotient	none	5	0.05	0.83	0.32	0.30	1-2 m
Copper Quotient	none	5	0.21	1.65	0.57	0.61	1-2 m
Lead Quotient	none	5	0.17	2.92	1.22	1.03	1-2 m
Mercury Quotient	none	5	0.17	1.40	0.79	0.45	1-2 m
Zinc Quotient	none	5	0.38	1.65	0.81	0.49	1-2 m

Naphthalene	ppb	5	54.00	220.00	130.80	65.90	1-2 m
C1-Naphthalenes	ppb	5	27.00	280.00	145.40	108.19	1-2 m
C2-Naphthalenes	ppb	5	65.00	410.00	210.00	149.71	1-2 m
C3-Naphthalenes	ppb	5	48.00	290.00	169.40	102.55	1-2 m
C4-Naphthalenes	ppb	5	48.00	260.00	155.20	88.34	1-2 m
Acenaphthylene	ppb	5	42.00	120.00	73.60	29.30	1-2 m
Acenaphthene	ppb	5	11.00	46.00	29.80	15.71	1-2 m
Biphenyl	ppb	5	13.00	51.00	28.80	15.85	1-2 m
Dibenzofuran	ppb	5	8.60	44.00	20.52	14.06	1-2 m
Fluorene	ppb	5	18.00	82.00	56.20	24.60	1-2 m
C1-Fluorenes	ppb	5	30.00	97.00	65.80	27.29	1-2 m
C2-Fluorenes	ppb	5	30.00	150.00	87.80	58.04	1-2 m
C3-Fluorenes	ppb	5	69.00	460.00	213.80	156.85	1-2 m
Anthracene	ppb	5	140.00	510.00	256.00	148.76	1-2 m
Phenanthrene	ppb	5	100.00	340.00	242.00	91.21	1-2 m
C1-Phenanthrenes/anthracenes	ppb	5	95.00	400.00	293.00	127.55	1-2 m
C2-Phenanthrenes/anthracenes	ppb	5	120.00	500.00	316.00	171.84	1-2 m
C3-Phenanthrenes/anthracenes	ppb	5	120.00	760.00	380.00	259.13	1-2 m
C4-Phenanthrenes/anthracenes	ppb	5	180.00	800.00	418.00	265.65	1-2 m
Dibenzothiophene	ppb	5	12.00	49.00	34.20	14.94	1-2 m
C1-Dibenzothiophenes	ppb	5	20.00	130.00	61.60	41.27	1-2 m
C2-Dibenzothiophenes	ppb	5	53.00	290.00	147.40	99.08	1-2 m
C3-Dibenzothiophenes	ppb	5	43.00	690.00	254.60	254.78	1-2 m
Fluoranthene	ppb	5	190.00	950.00	552.00	283.32	1-2 m
Pyrene	ppb	5	760.00	1500.00	1182.00	329.58	1-2 m
C1-Fluoranthenes/pyrenes	ppb	5	350.00	990.00	676.00	266.80	1-2 m

**APPENDIX C**  
**Summary Statistics**  
**Yosemite Creek**

Analyte	Units	n	Minimum	Maximum	Mean	Standard Deviation	Depth of Sample
C2-Fluoranthenes/pyrenes	ppb	5	200.00	780.00	442.00	237.00	1-2 m
C3-Fluoranthenes/pyrenes	ppb	5	89.00	720.00	341.80	238.42	1-2 m
Benzo[a]anthracene	ppb	5	210.00	610.00	420.00	156.20	1-2 m
Chrysene	ppb	5	180.00	620.00	428.00	164.07	1-2 m
C1-Chrysenes	ppb	5	190.00	500.00	350.00	126.89	1-2 m
C2-Chrysenes	ppb	5	100.00	520.00	294.00	166.97	1-2 m
C3-Chrysenes	ppb	5	84.00	470.00	250.80	157.84	1-2 m
C4-Chrysenes	ppb	5	53.00	410.00	210.60	145.99	1-2 m
Benzo[b]fluoranthene	ppb	5	520.00	1200.00	796.00	252.35	1-2 m
Benzo[k]fluoranthene	ppb	5	120.00	400.00	254.00	99.40	1-2 m
Benzo[e]pyrene	ppb	5	310.00	780.00	512.00	174.56	1-2 m
Benzo[a]pyrene	ppb	5	400.00	1100.00	700.00	253.67	1-2 m
Perylene	ppb	5	120.00	300.00	196.00	65.42	1-2 m
Indeno[1,2,3,-c,d]pyrene	ppb	5	260.00	630.00	418.00	133.87	1-2 m
Dibenzo[a,h]anthracene	ppb	5	38.00	90.00	62.60	19.79	1-2 m
Benzo[g,h,i]perylene	ppb	5	220.00	560.00	374.00	123.21	1-2 m
LONG AND MORGAN PAH	ppb	5	1540.60	4809.00	3174.92	1236.77	1-2 m
ADL TOTAL PAH	ppb	5	6497.80	18399.35	12564.49	4680.44	1-2 m
LOW PAHS QUOTIENT	none	5	0.13	0.49	0.30	0.13	1-2 m
HIGH PAHS QUOTIENT	none	5	0.19	0.44	0.35	0.11	1-2 m
C10B-Phenyl decanes	ppb	5	0.17	73.00	29.18	37.80	1-2 m
C11B-Phenyl undecanes	ppb	5	0.17	130.00	26.54	57.84	1-2 m
C12B-Phenyl dodecanes	ppb	5	0.17	4.45	1.42	1.80	1-2 m
C13B-Phenyl tridecanes	ppb	5	13.00	970.00	256.20	403.26	1-2 m
C14B-Phenyl tetradecanes	ppb	5	0.17	4.45	1.42	1.80	1-2 m
n-Nonane	ppb	5	0.10	2.60	0.82	1.05	1-2 m
n-Decane	ppb	5	0.00	0.74	0.24	0.29	1-2 m
n-Undecane	ppb	5	0.01	0.30	0.12	0.12	1-2 m
n-Dodecane	ppb	5	0.01	0.30	0.10	0.12	1-2 m
n-Tridecane	ppb	5	0.02	0.40	0.13	0.16	1-2 m
Isoprenoid RRT 1380	ppb	5	0.04	0.97	0.35	0.36	1-2 m
n-Tetradecane	ppb	5	0.03	0.60	0.19	0.24	1-2 m
Isoprenoid RRT 1470	ppb	5	0.05	0.50	0.23	0.19	1-2 m
n-Pentadecane	ppb	5	0.01	0.26	0.09	0.10	1-2 m
n-Hexadecane	ppb	5	0.01	0.14	0.05	0.05	1-2 m
Isoprenoid RRT 1650	ppb	5	0.05	0.38	0.22	0.14	1-2 m
n-Heptadecane	ppb	5	0.21	1.50	0.88	0.58	1-2 m
Pristane	ppb	5	0.10	0.88	0.42	0.33	1-2 m
n-Octadecane	ppb	5	0.01	0.35	0.11	0.14	1-2 m
Phytane	ppb	5	0.08	0.83	0.47	0.33	1-2 m
n-Nonadecane	ppb	5	0.01	0.17	0.05	0.07	1-2 m
n-Eicosane	ppb	5	0.00	0.11	0.04	0.04	1-2 m
n-Heneicosane	ppb	5	0.01	3.00	0.99	1.22	1-2 m
n-Docosane	ppb	5	0.02	0.54	0.20	0.21	1-2 m
n-Tricosane	ppb	5	0.05	0.44	0.21	0.15	1-2 m
n-Tetracosane	ppb	5	0.01	0.26	0.08	0.11	1-2 m
n-Pentacosane	ppb	5	0.02	0.31	0.12	0.11	1-2 m
n-Hexacosane	ppb	5	0.01	0.16	0.07	0.06	1-2 m
n-Heptacosane	ppb	5	0.02	0.48	0.23	0.21	1-2 m
n-Octacosane	ppb	5	0.19	1.30	0.82	0.48	1-2 m
n-Nonacosane	ppb	5	0.51	1.50	1.03	0.36	1-2 m
n-Triacontane	ppb	5	0.03	0.41	0.16	0.15	1-2 m
n-Hentriacontane	ppb	5	0.30	2.10	1.14	0.90	1-2 m
n-Dotriacontane	ppb	5	0.02	1.60	0.53	0.65	1-2 m

**APPENDIX C**  
**Summary Statistics**  
**Yosemite Creek**

Analyte	Units	n	Minimum	Maximum	Mean	Standard Deviation	Depth of Sample
n-Tritriacontane	ppb	5	0.08	1.80	0.81	0.75	1-2 m
n-Tetratriacontane	ppb	5	0.02	0.61	0.19	0.24	1-2 m
n-Pentatriacontane	ppb	5	0.01	1.70	0.55	0.76	1-2 m
n-Hexatriacontane	ppb	5	0.01	0.60	0.18	0.25	1-2 m
n-Heptatriacontane	ppb	5	0.01	0.34	0.12	0.15	1-2 m
n-Octatriacontane	ppb	5	0.01	0.34	0.11	0.15	1-2 m
n-Nonatriacontane	ppb	5	0.01	0.17	0.05	0.07	1-2 m
n-Tetracontane	ppb	5	0.01	0.17	0.06	0.07	1-2 m
Total Resolved Hydrocarbons	ppb	5	36.00	380.00	149.20	133.13	1-2 m
Total Petroleum Hydrocarbons	ppb	5	310.00	4200.00	1762.00	1454.55	1-2 m
TPH >C8-C10	ppb	5	0.65	39.00	9.77	16.38	1-2 m
TPH >C10-C12	ppb	5	2.10	190.00	44.92	81.22	1-2 m
TPH >C12-C16	ppb	5	8.60	230.00	73.52	88.92	1-2 m
TPH >C16-C21	ppb	5	47.00	660.00	259.40	237.00	1-2 m
TPH >C21-C25	ppb	5	60.00	720.00	318.00	245.19	1-2 m
TPH >C25-C30	ppb	5	84.00	960.00	446.80	319.92	1-2 m
TPH >C30-C35	ppb	5	62.00	740.00	344.40	248.99	1-2 m
TPH >C35 +	ppb	5	45.00	640.00	283.00	222.98	1-2 m

Heptachlor	ppb	5	0.06	1.20	0.30	0.50	1-2 m
Aldrin	ppb	5	0.07	1.80	0.51	0.75	1-2 m
alpha-Chlordane	ppb	5	1.30	21.00	10.36	8.29	1-2 m
gamma-Chlordane	ppb	5	0.06	39.00	21.41	16.75	1-2 m
cis-Nonachlor	ppb	5	1.10	3.70	2.60	1.03	1-2 m
2,4'-DDT	ppb	5	0.10	0.16	0.13	0.02	1-2 m
4,4'-DDT	ppb	5	0.15	36.00	12.10	16.88	1-2 m
2,4'-DDE	ppb	5	0.13	28.00	6.32	12.19	1-2 m
4,4'-DDE	ppb	5	30.00	88.00	60.60	25.29	1-2 m
2,4'-DDD	ppb	5	0.08	39.00	9.85	16.73	1-2 m
4,4'-DDD	ppb	5	0.17	130.00	43.31	52.34	1-2 m
TOTAL DDT	ppb	5	50.86	235.46	132.32	74.11	1-2 m
Dieldrin	ppb	5	21.00	120.00	78.40	39.90	1-2 m
Endrin	ppb	5	0.06	0.09	0.08	0.01	1-2 m
Heptachlor Epoxide	ppb	5	0.06	0.09	0.08	0.01	1-2 m
lindane	ppb	5	0.05	0.07	0.06	0.01	1-2 m
Mirex	ppb	5	0.03	0.05	0.04	0.01	1-2 m
trans-Nonachlor	ppb	5	1.10	10.00	6.22	3.22	1-2 m
TOTAL CHLORDANE	ppb	5	3.37	68.80	40.55	27.16	1-2 m
CHLORDANE QUOTIENT	none	5	0.56	11.47	6.76	4.53	1-2 m
DDT QUOTIENT	none	5	0.04	0.09	0.07	0.02	1-2 m
DIELDRIN QUOTIENT	none	5	2.63	15.00	9.80	4.99	1-2 m

**APPENDIX C**  
**Summary Statistics**  
**Yosemite Creek**

Analyte	Units	n	Minimum	Maximum	Mean	Standard Deviation	Depth of Sample
8 - 2,4'-Dichlorobiphenyl (C12)	ppb	5	0.05	1.70	1.23	0.67	1-2 m
18 - 2,2',5'-Trichlorobiphenyl (C13)	ppb	5	0.52	4.10	2.36	1.28	1-2 m
28 - 2,4,4'-Trichlorobiphenyl (C13)	ppb	5	1.40	6.30	3.80	1.78	1-2 m
44 - 2,2',3,5'-Tetrachlorobiphenyl (C14)	ppb	5	3.90	14.00	10.06	4.27	1-2 m
52 - 2,2',5,5'-Tetrachlorobiphenyl (C14)	ppb	5	8.90	27.00	19.78	6.95	1-2 m
66 - 2,3',4,4'-Tetrachlorobiphenyl (C14)	ppb	5	15.00	46.00	30.20	12.32	1-2 m
77 - 3,3',4,4'-Tetrachlorobiphenyl (C14)	ppb	5	0.05	0.08	0.06	0.01	1-2 m
101 - 2,2',4,5,5'-Pentachlorobiphenyl (C15)	ppb	5	22.00	64.00	43.40	16.67	1-2 m
105 - 2,3,3',4,4'-Pentachlorobiphenyl (C15)	ppb	5	7.80	27.00	18.56	8.02	1-2 m
118 - 2,3',4,4',5'-Pentachlorobiphenyl (C15)	ppb	5	8.20	64.00	36.04	23.99	1-2 m
126 - 3,3',4,4',5'-Pentachlorobiphenyl (C15)	ppb	5	0.08	0.12	0.10	0.01	1-2 m
128 - 2,2',3,3',4,4'-Hexachlorobiphenyl (C16)	ppb	5	7.40	19.00	13.48	5.25	1-2 m
138 - 2,2',3,4,4',5'-Hexachlorobiphenyl (C16)	ppb	5	56.00	180.00	112.40	48.21	1-2 m
153 - 2,2',4,4',5,5'-Hexachlorobiphenyl (C16)	ppb	5	37.00	120.00	71.80	34.40	1-2 m
170 - 2,2',3,3',4,4',5'-Heptachlorobiphenyl (C17)	ppb	5	22.00	85.00	48.80	27.40	1-2 m
180 - 2,2',3,4,4',5,5'-Heptachlorobiphenyl (C17)	ppb	5	30.00	120.00	70.00	38.10	1-2 m
187 - 2,2',3,4',5,5',6'-Heptachlorobiphenyl (C17)	ppb	5	17.00	56.00	34.00	16.25	1-2 m
195 - 2,2',3,3',4,4',5,6'-Octachlorobiphenyl	ppb	5	3.30	13.00	7.20	4.05	1-2 m
206 - 2,2',3,3',4,4',5,5',6'-Nonachlorobiphenyl (C17)	ppb	5	1.80	7.00	3.90	2.15	1-2 m
209 - 2,2',3,3',4,4',5,5',6,6'-Decachlorobiphenyl (C110)	ppb	5	0.77	2.70	1.71	0.96	1-2 m
Total PCB Congeners	ppb	5	270.00	860.00	528.00	245.30	1-2 m
BPTCP PCBs	ppb	5	271.44	856.80	528.72	243.05	1-2 m
Total Aroclor 1016	ppb	5	4.25	50.00	31.83	24.88	1-2 m
Total Aroclor 1221	ppb	5	4.25	50.00	31.83	24.88	1-2 m
Total Aroclor 1232	ppb	5	4.25	50.00	31.83	24.88	1-2 m
Total Aroclor 1242	ppb	5	4.25	50.00	31.83	24.88	1-2 m
Total Aroclor 1248	ppb	5	4.25	50.00	31.83	24.88	1-2 m
Total Aroclor 1260	ppb	5	230.00	820.00	476.00	248.56	1-2 m
Total Aroclor 1254	ppb	5	290.00	920.00	674.00	276.46	1-2 m
PCB QUOTIENT	none	5	1.51	4.76	2.94	1.35	1-2 m

**APPENDIX D**

**SOURCE IDENTIFICATION OF CONTAMINANTS**

## Characterization of Contaminant Sources

### Technical Approach

Advanced chemical fingerprinting (ACF) was used to rigorously characterize the contamination detected in the sediments of Yosemite Creek. ACF employs core analytical methods that are selected and tailored for the characterization of petroleum and chlorinated (e.g., PCB) contaminants. The specific utility of any particular class of compounds to "fingerprint" a sample however depends on the following:

- ability to resolve products from different geological sources
- relative state of weathering (or aging) of the material
- presence of specific product additives and refinery process signatures
- availability of reference source materials
- identification of congener and Aroclor types

For this program, the ACF study was designed with specific consideration to potential sources. The core analyses include a full range of target compounds with the ability to identify chemical differences and similarities within the sample set.

### Chemical Analysis

The following analyses were performed and are used in the characterization of potential sources:

- Saturated and total hydrocarbons by gas chromatography/flame ionization detection (GC/FID)
- polynuclear aromatic hydrocarbons by gas chromatography/mass spectrometry in the selected ion mode (GC/MS/SIM)
- Polychlorinated biphenyl (PCB) congeners PCB congener analysis by gas chromatography/electron capture detection (GC/ECD)

The following sections briefly describe the analyses performed and the use of the analytical results in the ACF study.

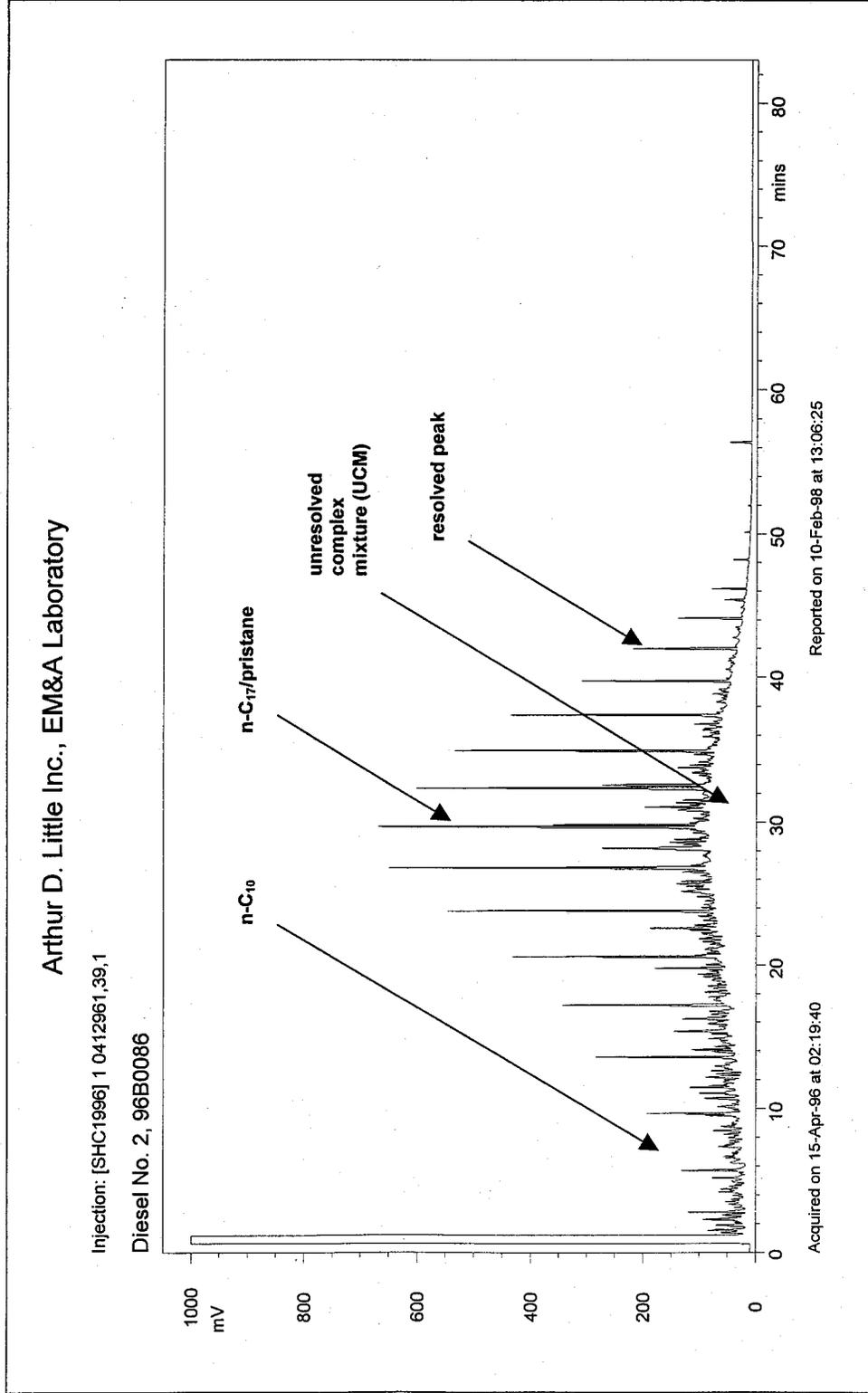
#### ***Saturated and Total Hydrocarbons by Gas Chromatography/Flame Ionization Detection (GC/FID)***

Samples were analyzed for target saturated hydrocarbons including C<sub>8</sub> through C<sub>40</sub> normal alkanes using GC/FID. Also included in the list of target analytes are selected isoprenoids (i.e., branched alkanes), such as pristane and phytane. The analysis of saturated hydrocarbons provides compositional information for a product, including concentrations of normal alkanes and total hydrocarbon content. Further, because product weathering follows a documented chemical path with compounds aging at different rates, ratios of select constituents may indicate relative weathering states.

The GC/FID chromatogram from this analysis provides a visual characterization of the product that can be used for comparison to other samples and reference materials analyzed under similar chromatographic conditions. An example of a GC/FID chromatogram is provided as Figure 1.

The GC/FID chromatogram provides a chemical picture of the sample that can be used to identify product type, source, and degree of weathering. Chemical linkages between samples may be inferred by the distribution of resolved hydrocarbons (clearly defined peaks), including normal alkanes (e.g., n-C<sub>8</sub>, octane) and the retention time of the unresolved complex mixture (UCM). Resolved hydrocarbons are compounds that can be chromatographically distinguished as peaks as compared to the UCM, which appears as a chromatographic "hump." As oil degrades, the resolved compounds are selectively removed and the UCM shape shifts from left to right toward the higher molecular weight constituents that are more resistant to degradation.

Figure 1: GC/FID Chromatogram of Diesel Fuel



### ***Polynuclear Aromatic Hydrocarbons by Gas Chromatography/Mass Spectrometry in the Selected Ion Mode (GC/MS/SIM)***

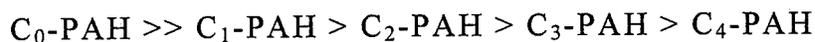
Samples were also analyzed for target PAH compounds using mass spectrometry in the selected ion mode. The instrumentation is configured to provide for the detection of target compounds at trace levels. For this study, the target list included two-, three-, four-, five-, and six-ring PAH compounds. Results for the alkyl-substituted PAHs series (e.g., total C<sub>1</sub> naphthalenes, total C<sub>2</sub> naphthalenes) and selected sulfur-containing heterocyclic compounds, such as dibenzothiophene and alkylbenzothiophenes, were also calculated. Linear alkylbenzenes (LAB) were also included in the target list.

PAH distribution plots provide a visual depiction of PAH concentration and relative distribution in a products or environmental samples. An example of the PAH distribution of diesel fuel is provided as Figure 2.

The distribution of PAHs is a powerful product identification tool because distribution is dependent on product class, petroleum source, and refinery signature. For example, in diesel fuel (Figure 2), the relative proportion of naphthalenes to the other PAHs and the lack of chrysenes is a characteristic of this product type. Also the relative distribution of alkyl homologues relative to the parent PAH is a characteristic of a petroleum product. In the distribution plot, this appears as a "bell" curve and this can be generally described as:



On the other hand, combustion related contaminants, such as creosote and atmospheric dust, have a distinctive PAH distribution that is easily differentiated from petroleum PAHs (NRC 1985). The distribution for creosote is provided as Figure 3. In combustion-related contaminants, parent PAHs dominate the distribution, with rapid decreases in levels of alkylated PAHs. This can be described as:



The major PAHs in combustion-related contaminants are naphthalene, phenanthrene, fluoranthene and pyrene. The relative amounts of these PAHs will vary with source with light creosote oil having greater proportions of naphthalene than a heavier product such as coal tar.

Atmospheric dust has a PAH distribution similar to coal tar and creosote products but is extensively depleted of the lower molecular weight PAHs. The dominance of benzo(b)fluoranthene relative to fluoranthene, pyrene and the other 5-6 ring PAHs is a strong indication of atmospheric deposition (Figure 4). The fine particles that comprise atmospheric dust, dominated by 4-, 5-, and 6-ring PAHs, accumulate in watershed areas and highways and are carried to marine systems during rainfall events (Quinn reference). As the fine particles settle in marine depositional basins, total PAH concentrations can reach 10-1000 ppm (MADEP reference).

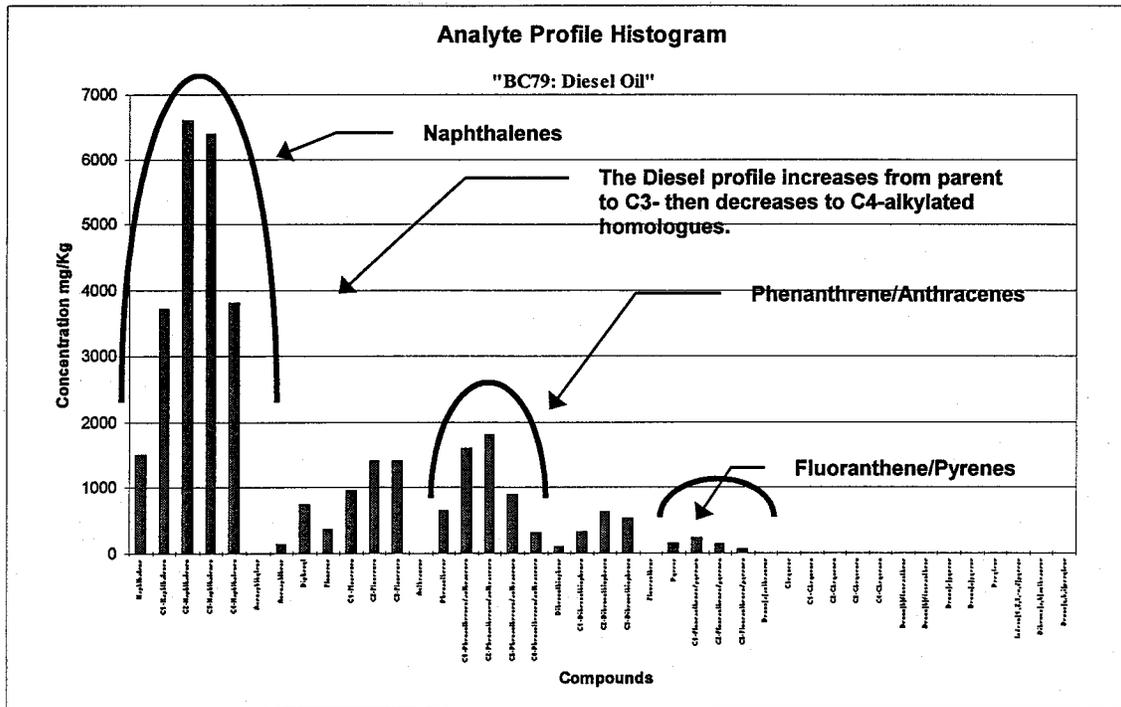
PAH distributions can be used to evaluate product degradation because degradation rates of PAH compounds generally decrease with increasing number of aromatic rings and degree of alkylation (number of attached carbon molecules). For example, naphthalene (a two-ring PAH) is more readily degraded than phenanthrene (a 3-ring PAH). Further, phenanthrene is more readily degraded than C<sub>4</sub>-phenanthrene. When PAH distributions are compared, the concentration data is sometimes normalized in the plot to one of the more degradation-resistant PAH compounds. This allows samples to be compared irrespective of absolute concentration; thus, it can provide information on relative PAH weathering between samples.

Alkylated PAH concentrations that dominate the PAH distribution in petroleum products are degraded in a predictable pattern (Elmendorf et al, 1994) with the C<sub>4</sub>-PAH being the most resistant to biodegradation. The biodegradation pathway of parent and alkylated PAHs results in a distinctive distribution pattern dominated by the more alkylated homologues of the parent PAH. This can generally be described as:



In terms of source relationships, because product weathering follows a documented chemical path, ratios of selected compounds can indicate relative weathering states. In the case of PAH compounds, compounds exist that degrade at similar rates, making their ratios relatively stable. These ratios may therefore be used as source indicators, even after the product has degraded (Douglas et al, 1996, Page et al, 1995).

**Figure 2: PAH Distribution Histogram – Diesel Reference Standard**



**Figure 3. PAH Distribution Histogram – Creosote Reference Standard**

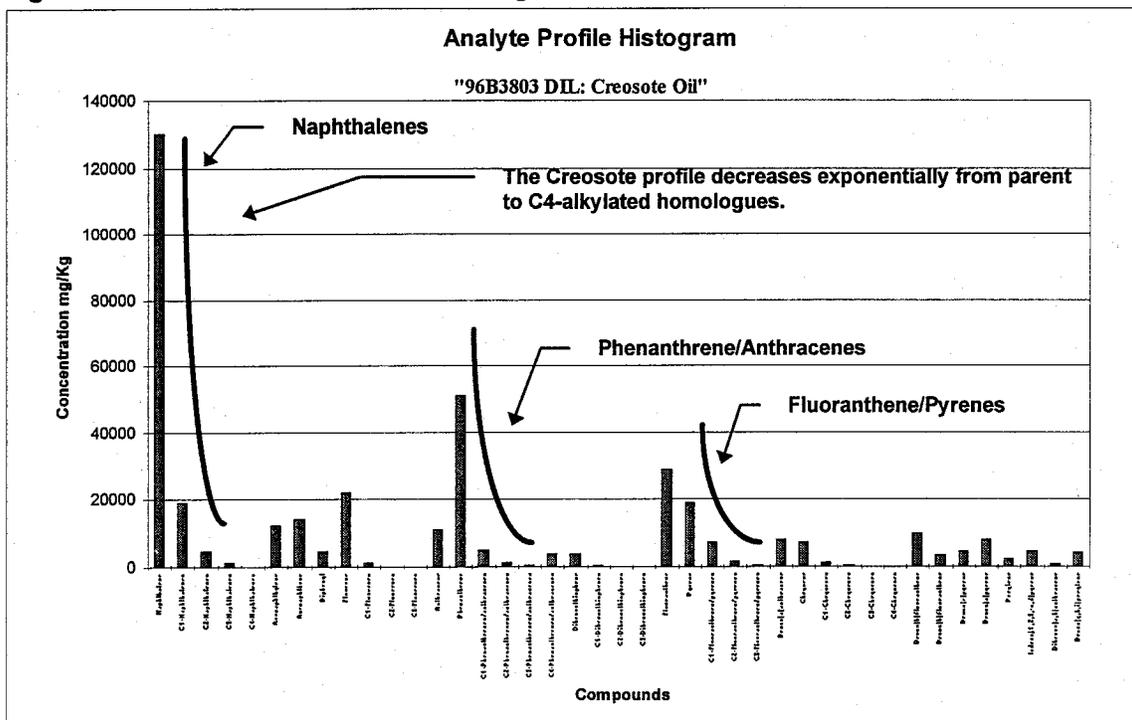
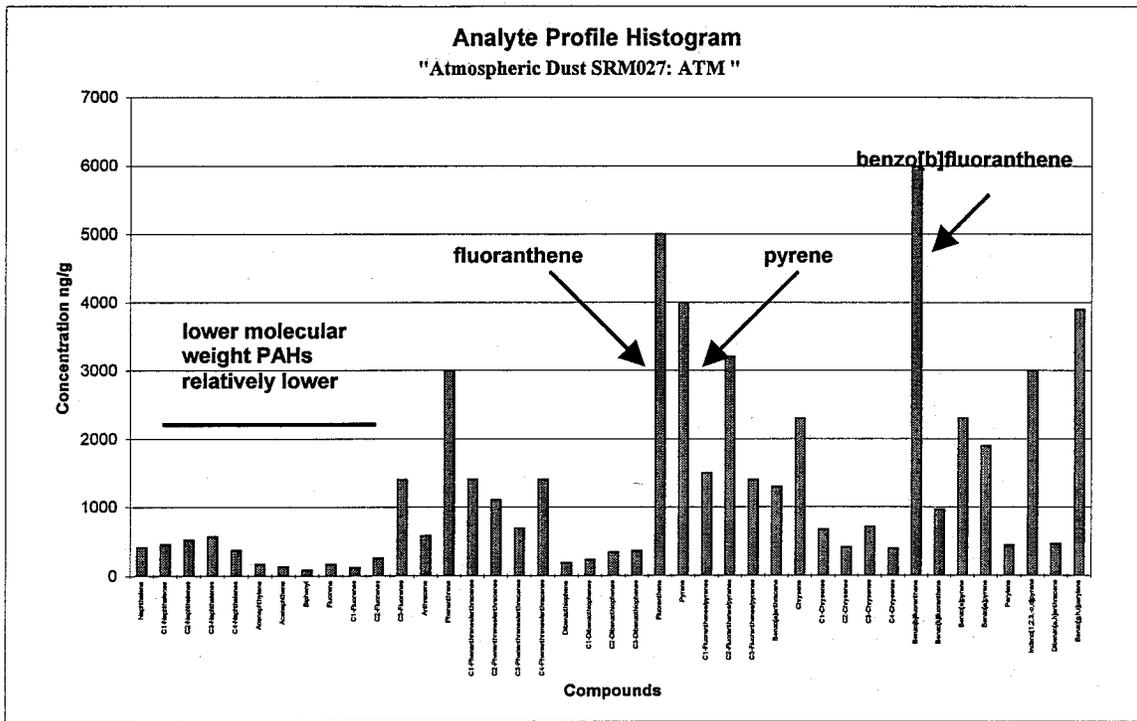


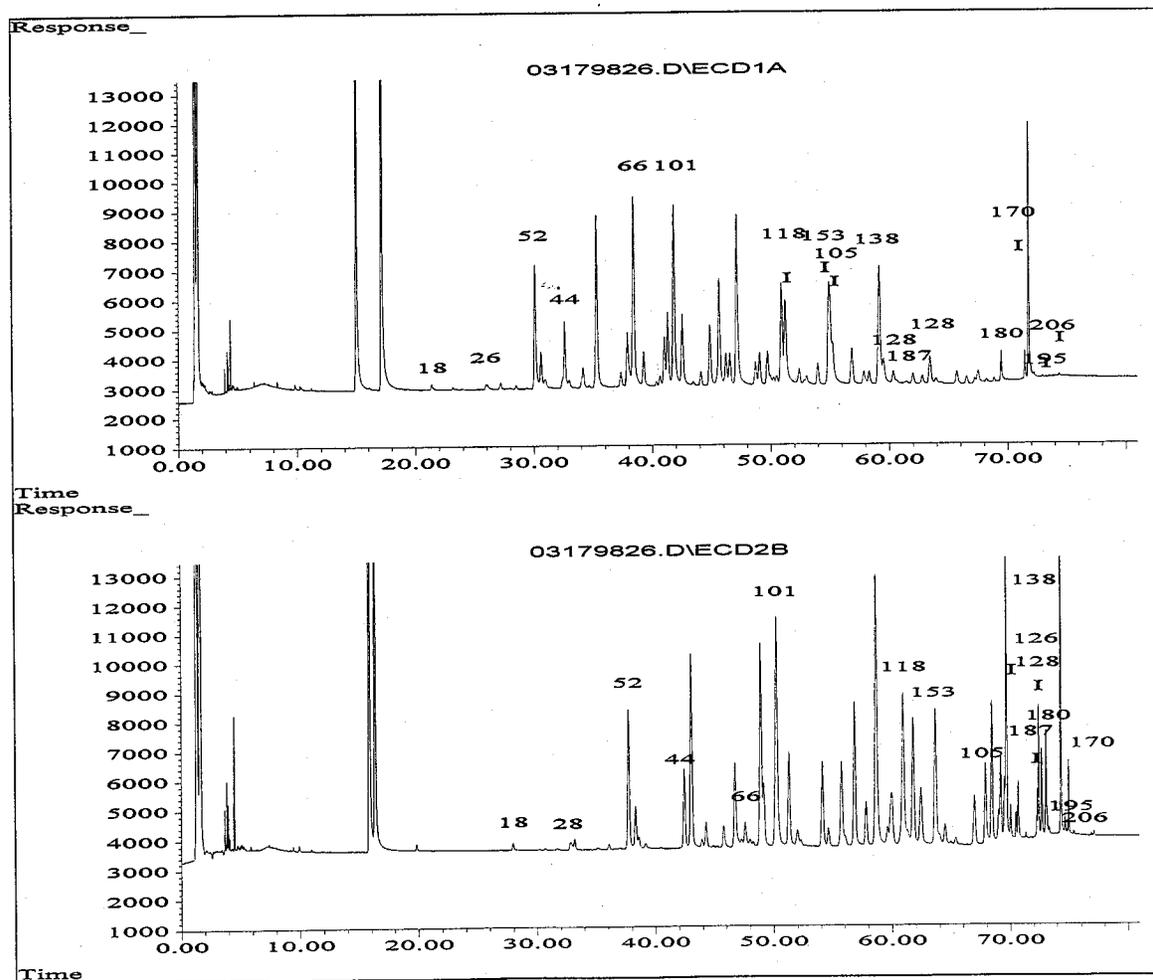
Figure 4: PAH Distribution - NIST Atmospheric Dust Standard



## Pesticides and PCB Congeners by Gas Chromatography/Electron Capture Detection (GC/ECD)

Samples were analyzed by GC/ECD for organochlorine pesticides and polychlorinated biphenyls (PCB). PCB Aroclors have a desirable chemical property and had a variety of industrial application before their use was restricted. Chemically, PCB Aroclors are comprised of individual polychlorinated biphenyls called congeners. Modern chromatographic techniques can separate and identify specific congeners which allows for evaluation of their distribution to identify the type of Aroclor and to assess weathering (Figure 5). Knowledge of the Aroclor type and relative proportion of Aroclors and congeners in the sediments may provide valuable source information.

**Figure 5: GC/ECD Chromatograms – Dual Column Analysis - Aroclor 1254 (Select Congeners Identified)**



## Reference Samples

Reference samples of standard products provide the foundation of a reliable forensic study. For this study, results of the analysis of environmental samples were compared to those of reference samples analyzed under similar conditions. Reference materials for the study were selected with consideration of the long history of industrial activity at the Yosemite Creek.

The following figures graphically present chemical characteristics of key reference samples. These are the basis for the discussions that follow.

Figure 6 – Unleaded Gasoline

Figure 7 – Kerosene

Figure 8 – Mineral Spirits

Figure 9 – Diesel Fuel

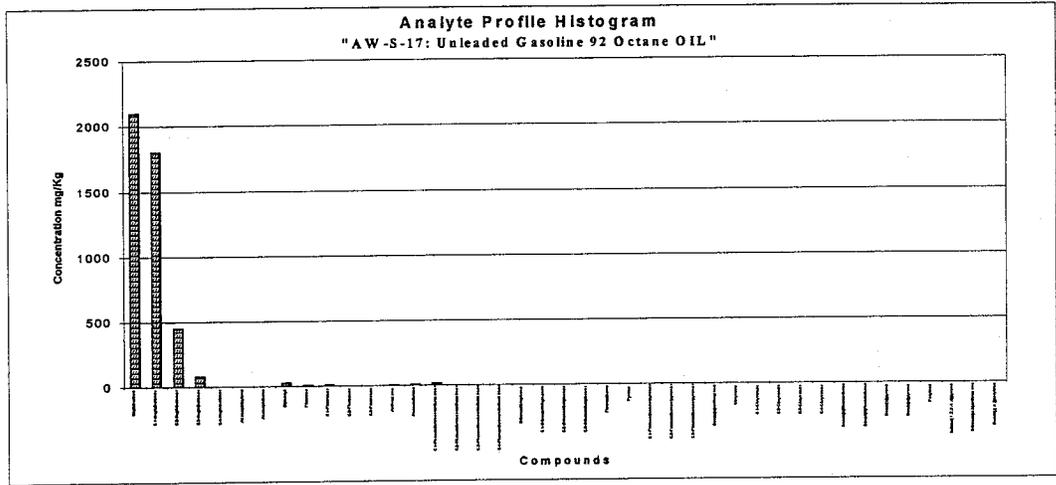
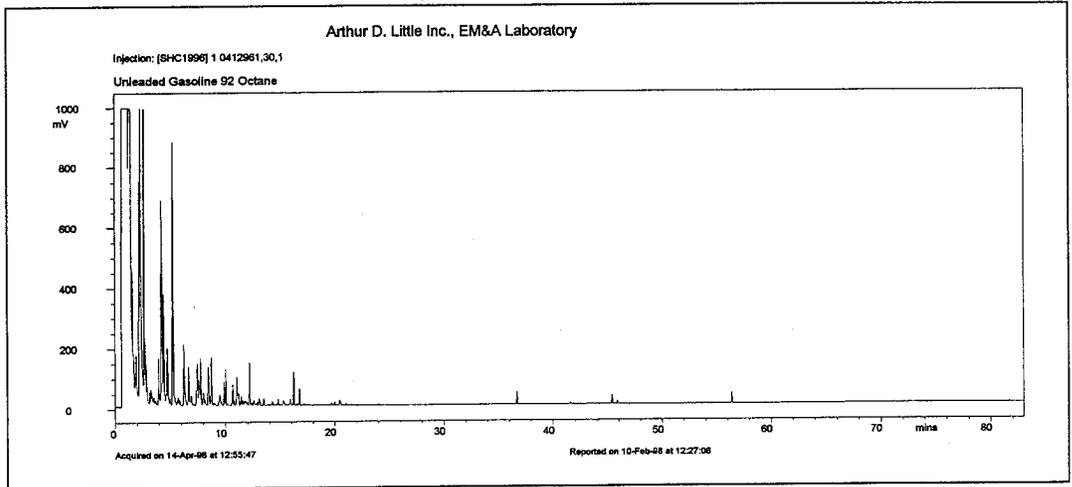
Figure 10 – Lubricating Oil

Figure 11 – Bunker C

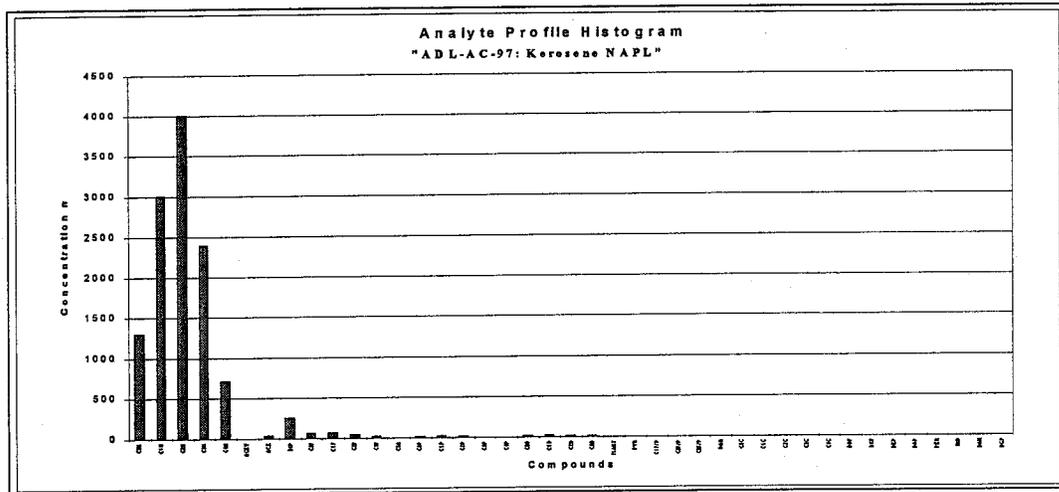
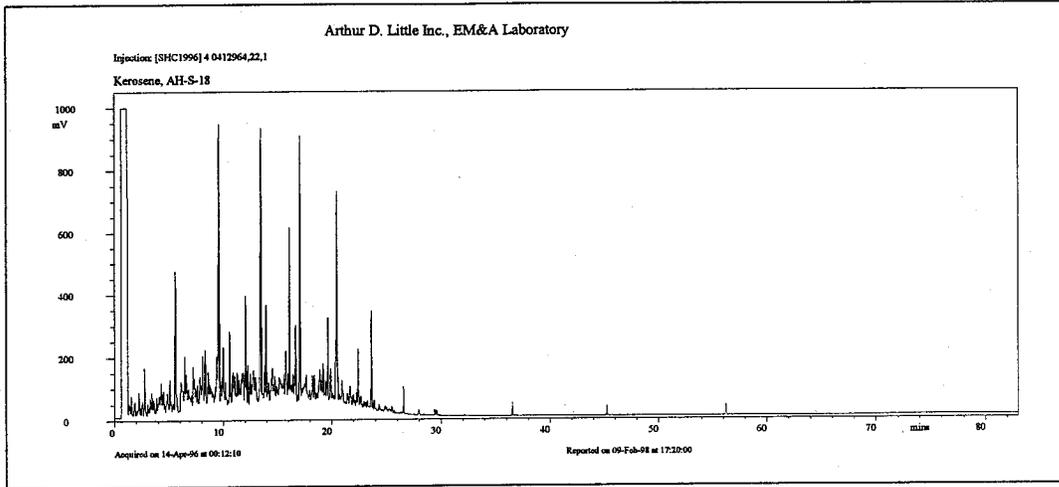
Figure 12 – Atmospheric Deposition

Figure 13 – Highway Runoff

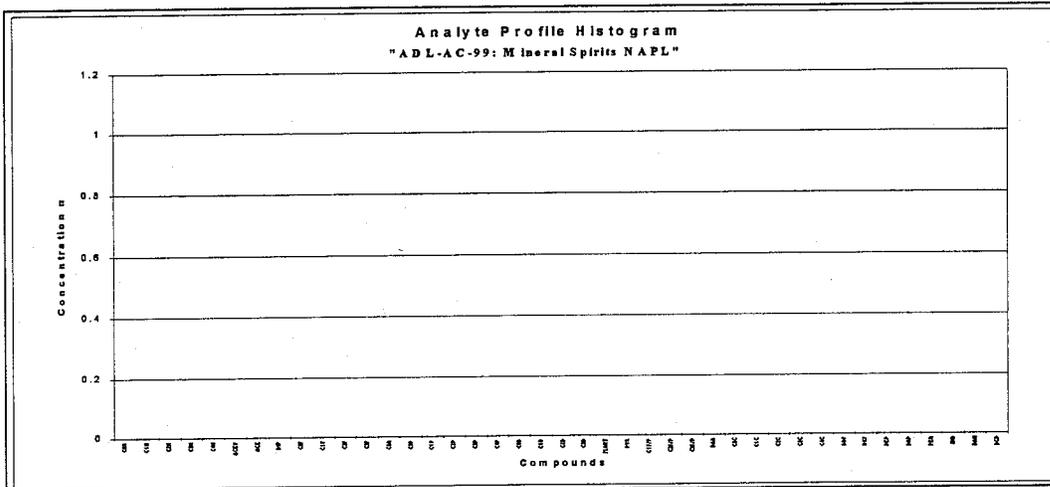
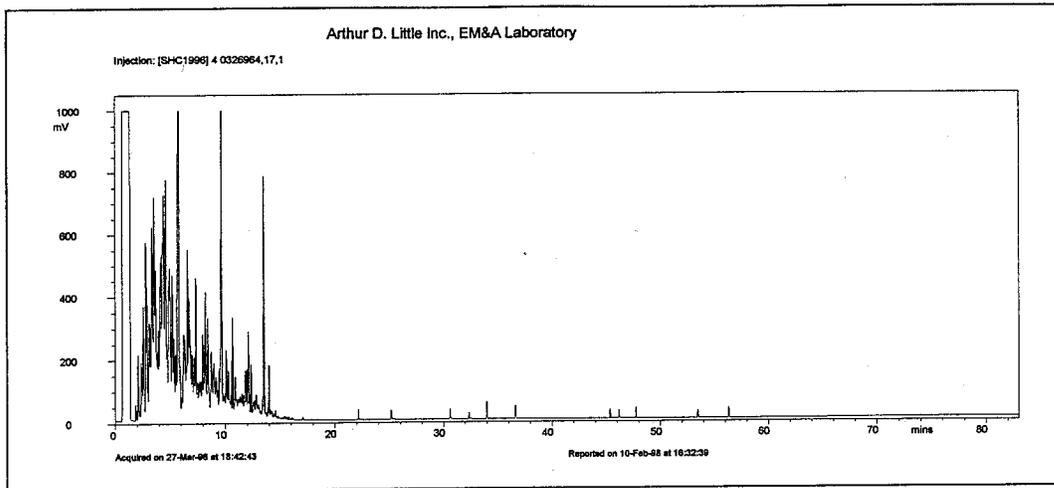
**Figure 6: Gasoline Sample - Advanced Chemical Fingerprinting Characteristics**



**Figure 7: Advanced Chemical Fingerprinting Characteristics – Kerosene**



**Figure 8: Advanced Chemical Fingerprinting Characteristics – Mineral Spirits**



**Figure 9: Advanced Chemical Fingerprinting Characteristics – Diesel Fuel**

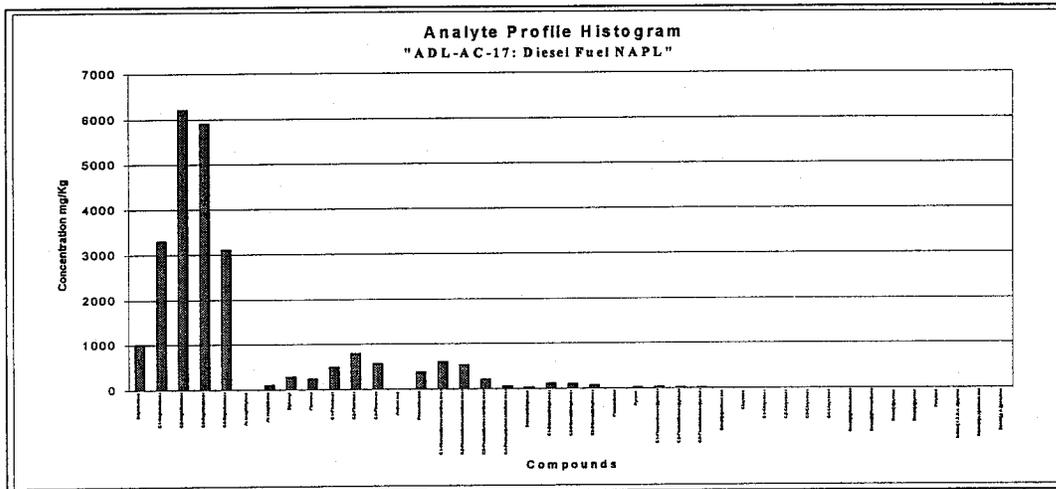
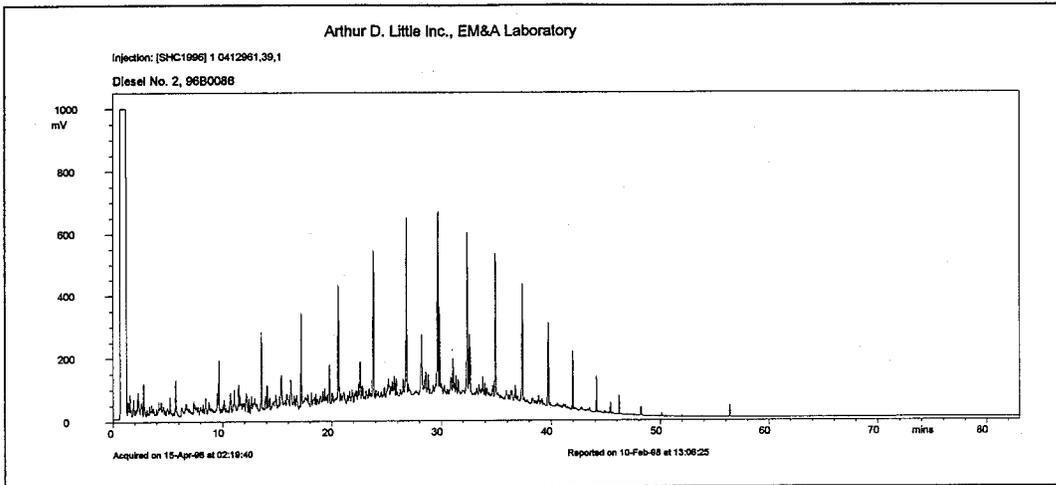


Figure 10: Advanced Chemical Fingerprinting Characteristics – Lubricating Oil

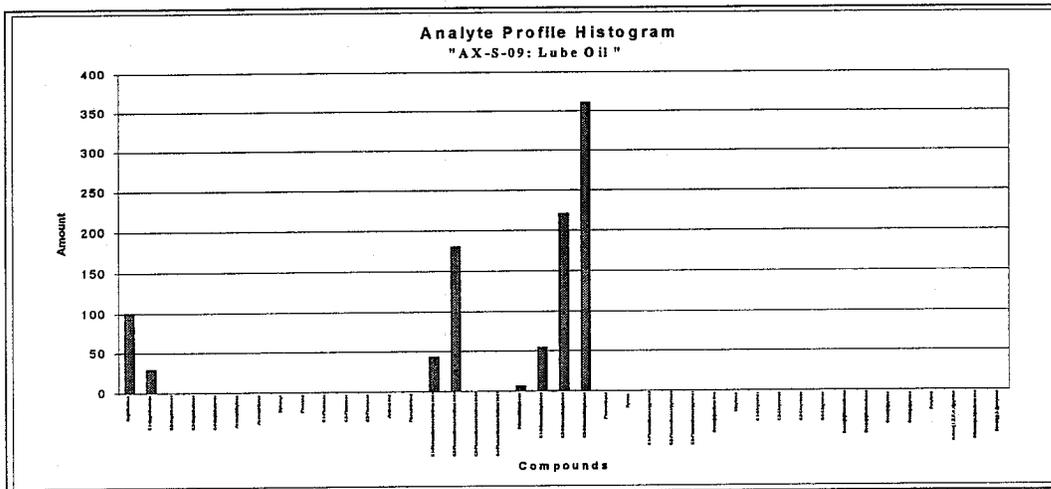
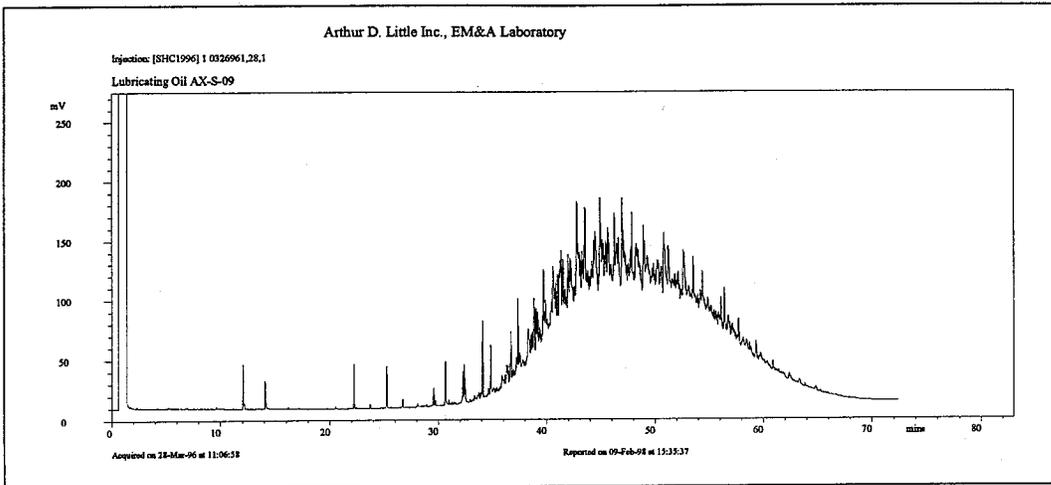
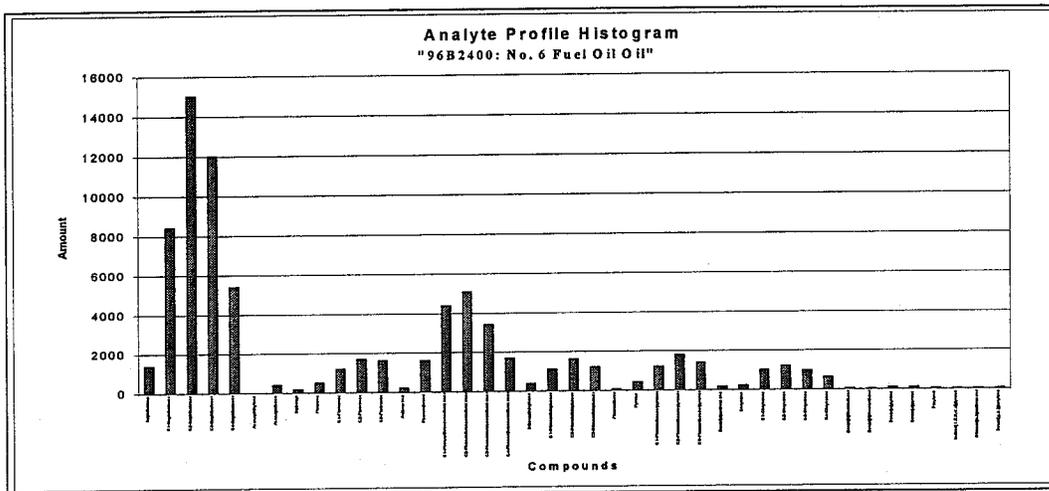
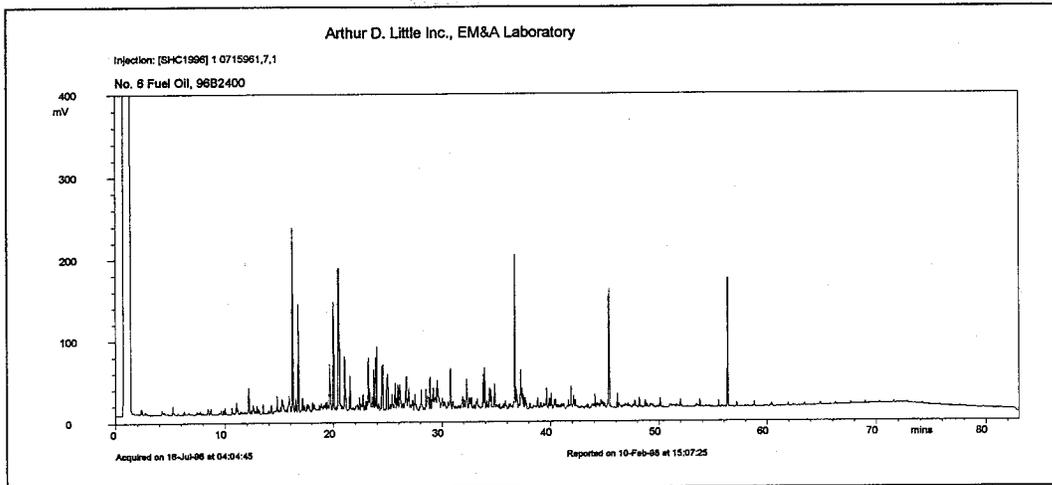
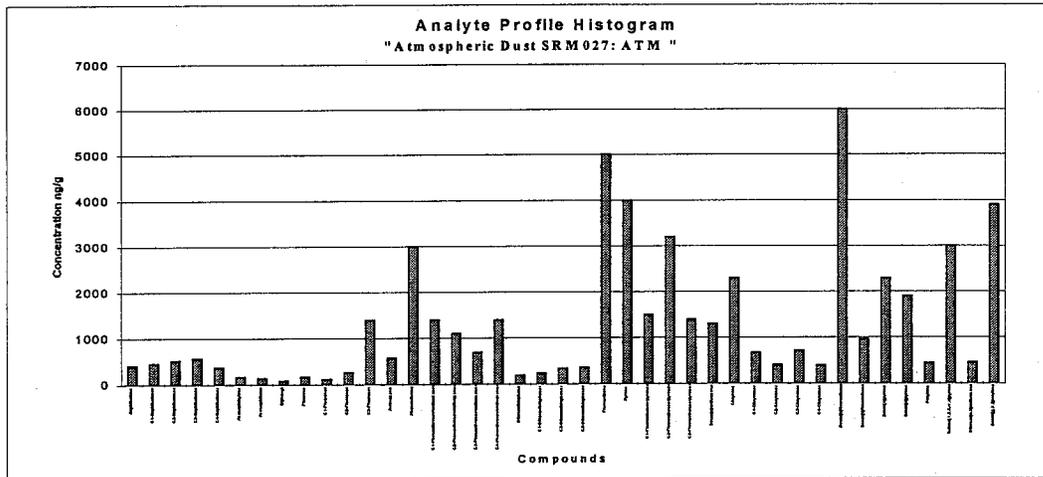
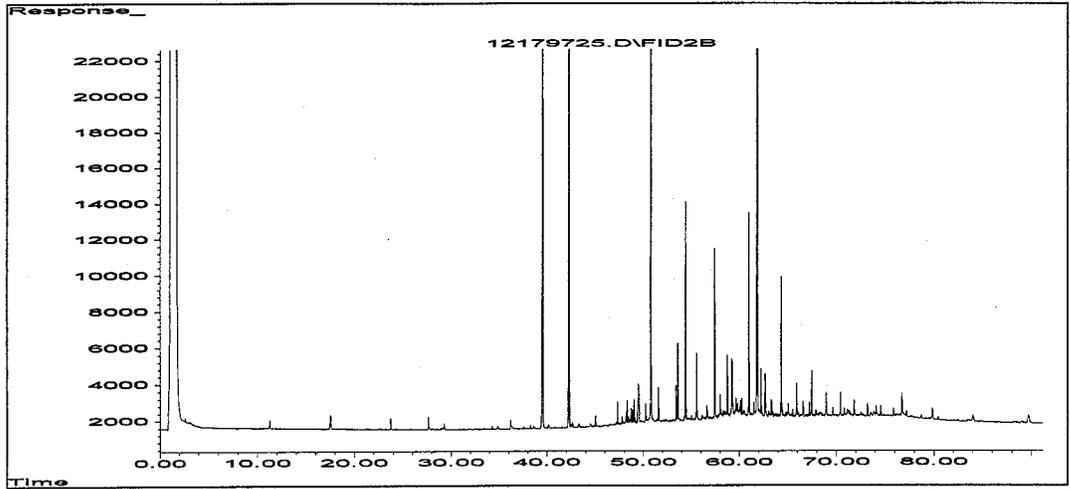


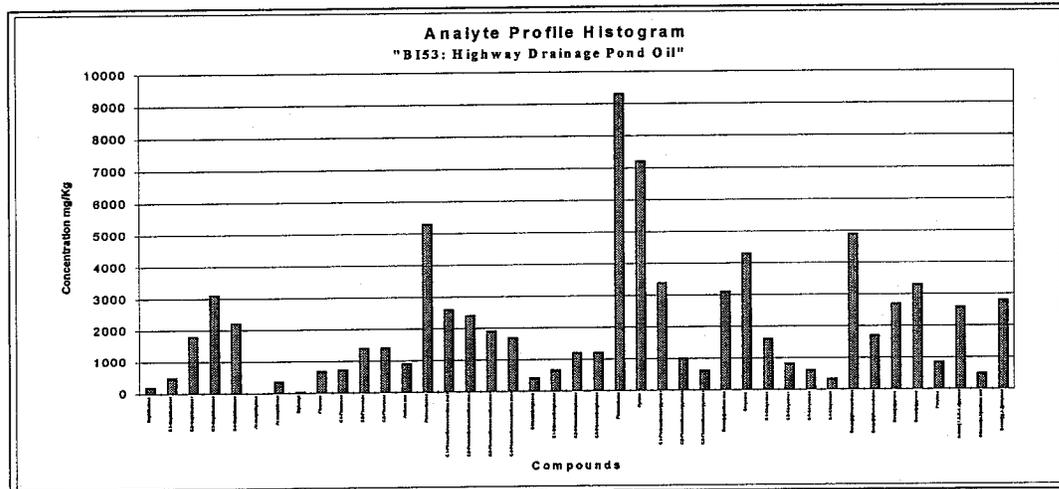
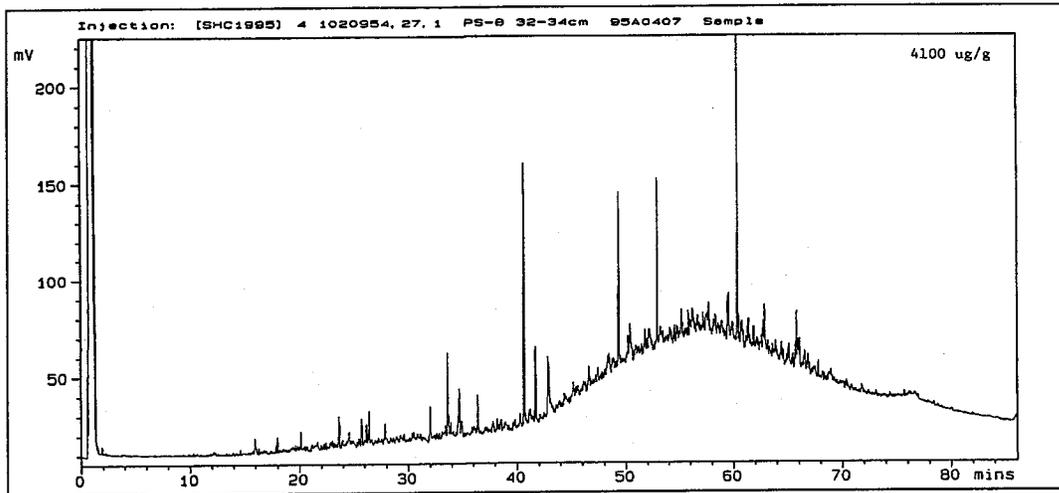
Figure 11: Advanced Chemical Fingerprinting Characteristics – Bunker C



**Figure 12: Advanced Chemical Fingerprinting Characteristics – Atmospheric Deposition**



**Figure 13: Advanced Chemical Fingerprinting Characteristics – Highway Runoff**



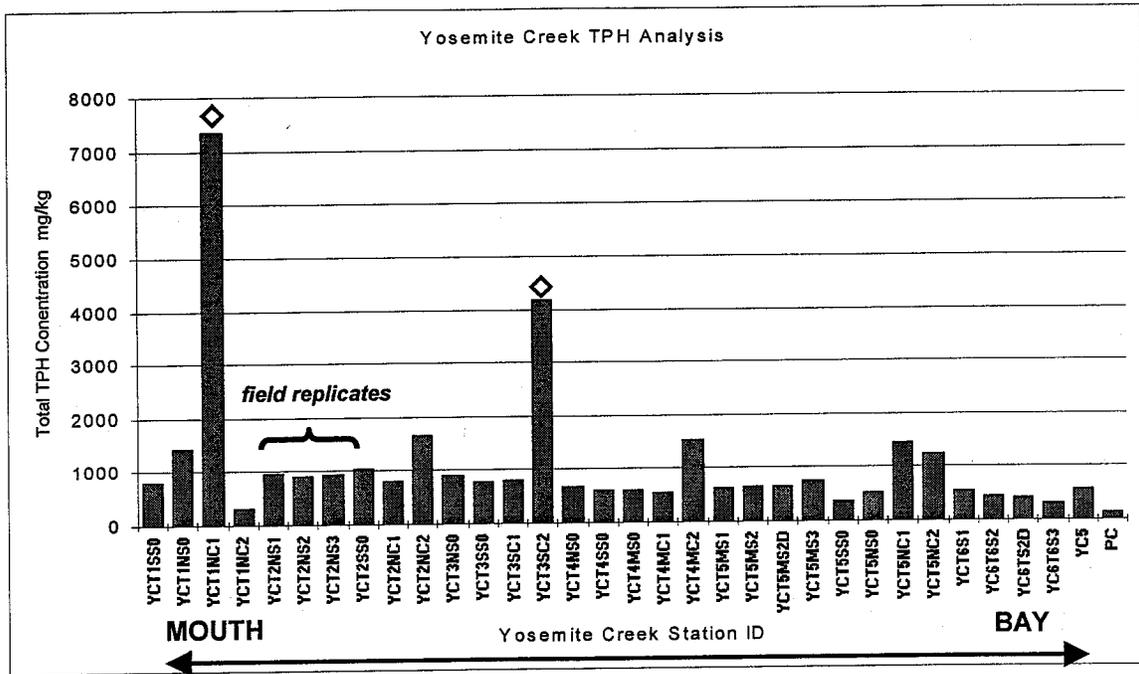
## Distribution of Hydrocarbons and Total PAHs in Creeks

Concentration of total petroleum hydrocarbons (TPH) and total PAHs (TPAH) measured in the creek sediments are presented as Figures 14 and 15. These data are useful to identify locations for further investigation in terms of contribution to total concentration as well as identification of the specific contaminant source. Hydrocarbon concentrations follow a generally decreasing trend from the mouth of the creek (Station 1) toward the bay (left to right in the figure). The highest TPH concentrations were observed in samples YCT1NC1 and YCT3SC2. The highest TPAH concentrations were observed in samples YCT1NC1 and YCT3SC3. The majority of the hydrocarbon contamination is found in samples from the upper creek with lower levels detected in the lower creek but still at concentrations higher (approximately 1 – 3 times) than that of the reference sample from Paradise Cove.

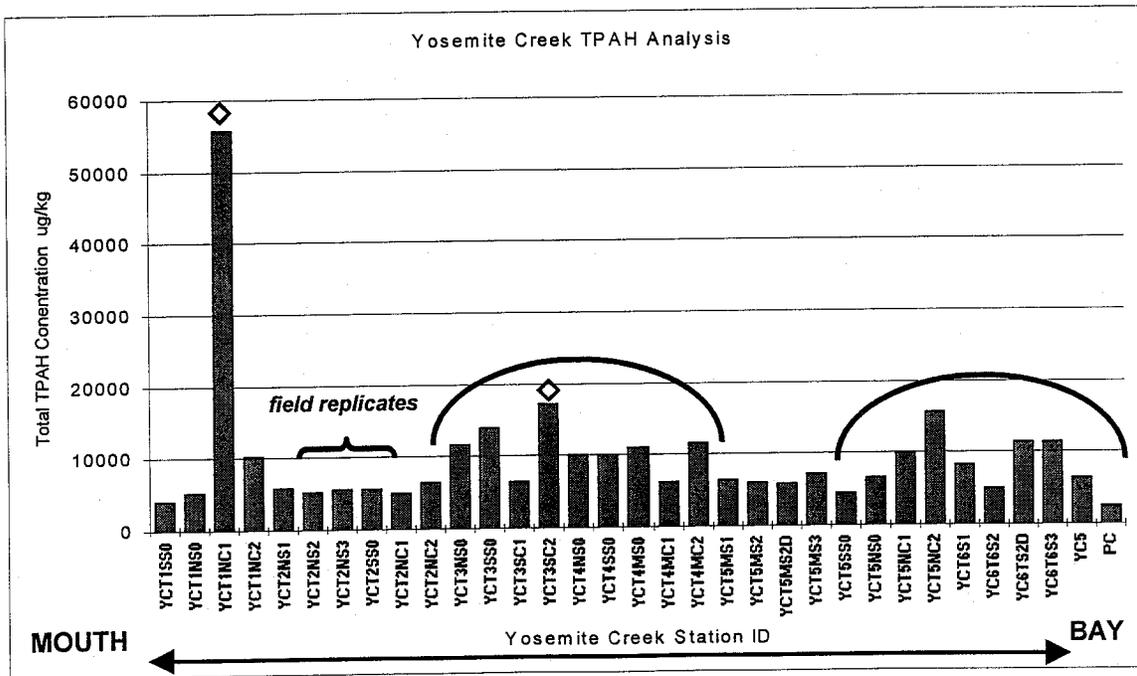
Comparison of the values also reveals that contaminant levels in the core samples are generally higher than those measured in the surface sediments, especially at the 2 foot depth. Compare for example the TPH level for sample YCT1NS0 versus that for sample YCT1NC1. The fact that concentrations are higher in the deeper sediments implies that hydrocarbon inputs may have been higher in the past although further investigation would be required to make such a conclusion. The TPH and TPAH distribution data will be used to identify the location of potential source samples in the Phase II study.

Where multiple surface samples were collected at a station, the TPH and TPAH variability was relatively small (e.g., YCT2NS1, YCT2NS2, YCT2NS3). This comparison is useful as a means to assess the quality of the data collected.

**Figure 14: Distribution of Total Petroleum Hydrocarbons in Creek Sediments**



**Figure 15: Distribution of Total PAHs in Creek Sediments**



## Interpretive Approach

Multiple interpretive approaches were used to evaluate the potential sources of contaminants to Yosemite Creek. The watershed surrounding Yosemite Creek has a history of heavy industrial activity as described in other sections. Potential source products from these activities include:

- Fuel oils
- Lubricating (machine) oils
- Coal tars
- PCBs

The first order interpretive analyses utilized Principal Component Analysis (PCA) to evaluate the PAH, LAB, and TPH data for both surface and core samples (one foot and two foot depths). Principal component analysis is a statistical method that analyzes highly correlated variables using non-linear multiple regression analysis, partial regression analysis, and least squares techniques. With PCA, a complex set of variables can be expressed in a simple graphical representation.

For evaluation of relationships of environmental samples, PCA has significant application. PCA is a multivariate data analysis technique that is used to identify and capture the important chemical information in a complex data matrix. It is then transformed into a smaller matrix of principal components that are linear combinations of the original data set. The analysis produces a scores parameter containing information about sample patterns in the data and a loadings parameter reflecting the influence each variable has on the sample pattern. The principal components (PC) are created in order of decreasing variance, so the first PC accounts for the most variance in the data, the second PC less, and so on.

This technique is used to:

- minimize bias when defining source relationships in large data sets
- explore the data set to determine how samples are related and what characteristics make them similar or different
- reduce large data sets to detect relationships and patterns that may have been missed or misinterpreted
- classify samples into related groups

For this study, statistical software (Sirius PRS Version 6) was used to perform the analysis. Other computer programs would produce similar results. The data set was first block-normalized then log normalized to minimize the impact of concentration on the sample relationships. This approach is standard for the analysis of environmental data. The results from the PCA analysis were then used to identify key samples for product source identification. During Phase 1 of this study, specific source samples were not collected from the Yosemite Creek watershed and an existing library of products was

used. The Phase 1 analysis will be used to identify potential source samples that will be collected during Phase 2.

### Principal Component Analysis Results

The results for the principal component analysis are presented in Figures 16 (scores) and Figure 17 (loadings). As discussed above the scores describe how the samples are related and the loadings explain why the samples are similar or dissimilar. The farther the loadings are from the origin, the larger the impact of that compounds on the variance. It is also possible that one relationship will drive the separation (e.g., TPH), however the sample may also contain compounds that are not described in the loadings. For example, the sample set may be driven by combustion PAHs versus heavy oil. Although the sample relation is driven by these two loadings, the heavy oil samples may also contain combustion PAHs (e.g., phenanthrene, fluoranthene, pyrene) and it is the lack of heavy oil in the samples with combustion PAHs that distinguishes the samples. Therefore, in the forensic investigation, it is critical that PCA be used as an exploratory tool to assist in the understanding of the sample relationships. Other interpretive tools such as GC/FID chromatograms (Douglas, et al, 1992), compound distribution plots (Page et al., 1995) and source ratio analysis (Douglas et al, 1996) must also be used to evaluate contamination sources.

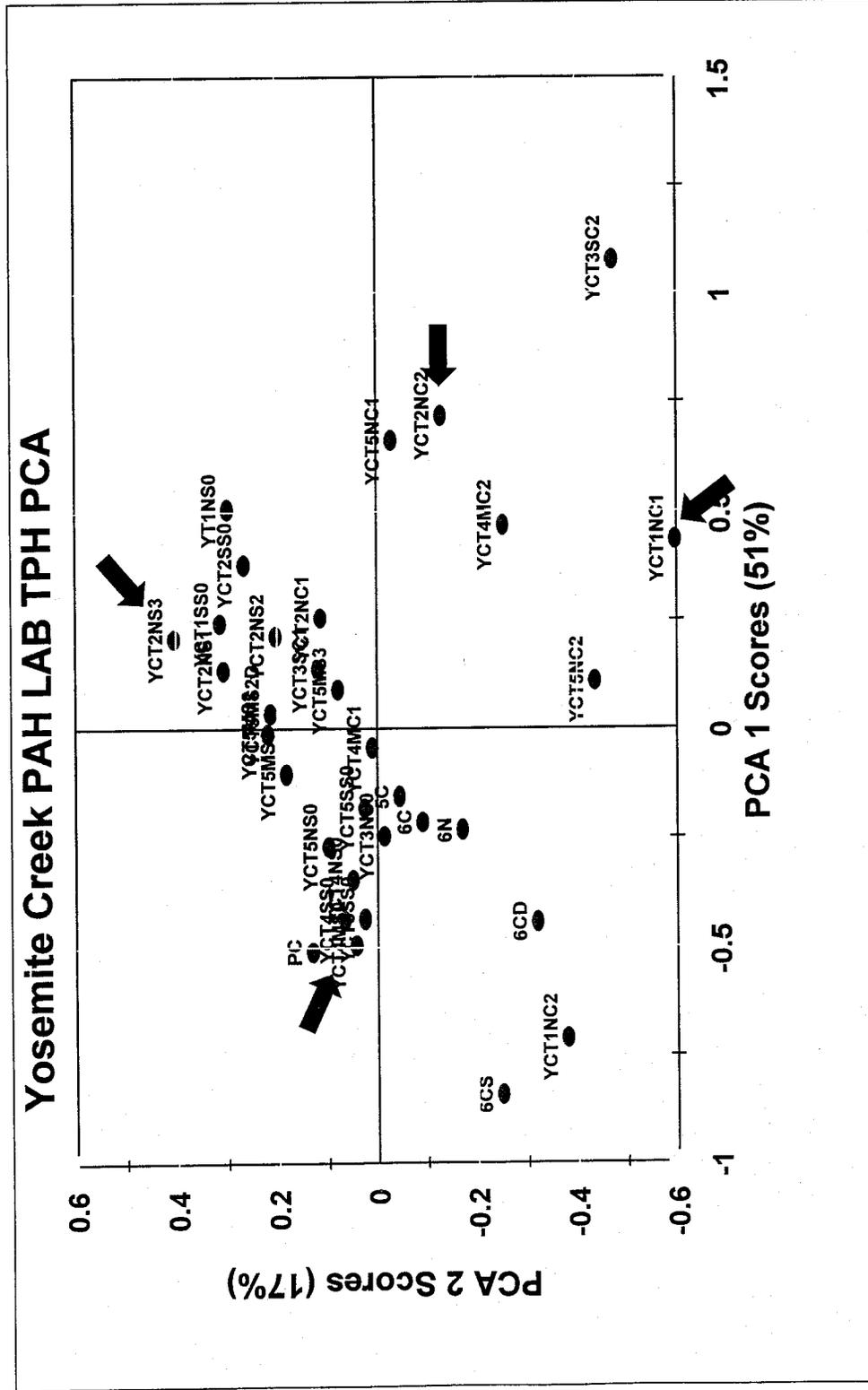
Figure 16 is the PCA Scores results for the PAH, LAB, and TPH results from samples collected in Yosemite Creek. Principal components 1 and 2 (PCA1 and PCA2) account for approximately 68% of the variance in the data set. The PAH analysis includes not only the EPA 16 priority pollutant PAH but the related alkylated PAHs as well. The alkylated PAHs are the major PAHs in petroleum products and provide important source specific information. The plot of the PCA loadings (Figure 17) indicates that alkylated PAHs are useful in the identification of petroleum products in this sample set. PCA1, graphed on the x-axis, is driven by the differences in pyrogenic (combustion related) and petrogenic (petroleum related) hydrocarbons in the sample set.

PCA2 on the y-axis also provides additional information concerning the nature of petroleum contamination at Yosemite Creek. Samples in the lower right of the plot are influenced by levels of alkylated PAHs in the phenanthrene and dibenzothiophene range which are hydrocarbons characteristic of light fuel oils such as diesel fuel and fuel oil #2 (Page, 1995). Those samples plotting in the upper right of the plot are more influenced by high molecular weight hydrocarbons (C<sub>20</sub> to C<sub>35</sub> boiling range) and alkylated chrysenes. These constituents are characteristic of heavy oil such as lubricating oil.

The samples from Yosemite Creek plot on the scores graph in all four quadrants. In addition, no clear single source appears to drive all of the samples collected and analyzed from a given station. This is indicative of source changes over time. For example, sample YCT1NSO is weighted toward the "heavy oil" quadrant (upper right), whereas a core sample from the same station, YCT1NC2, is weighted toward the combustion source quadrant (lower left). As suggested by the TPH and PAH distribution plots, the fact that the surface samples and the core samples are scattered on the loadings plot indicates that the contamination sources have changed with time.

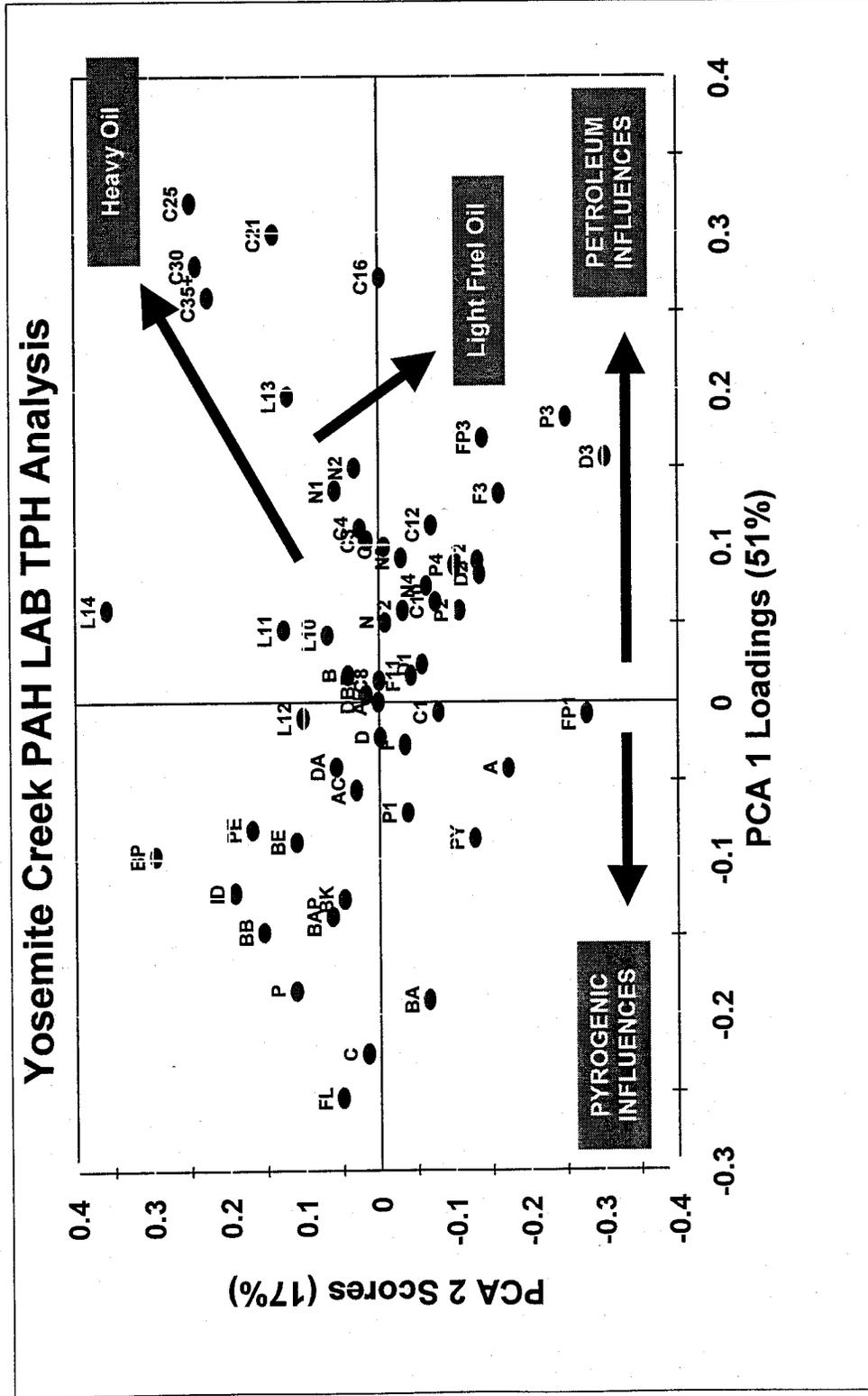
Based on the results of the PCA, the sources of contamination in Yosemite creek include heavy oils such as lubricating and fuel oils (e.g., sample YCT1NS0), light fuel oils such as diesel fuel (e.g., YCT3SC2), and combustion sources such as atmospheric deposition/coal tar (e.g., YCT1NC2). These sources will be further delineated in the Phase II study.

Figure 16: Principal Components Scores Plot



↓ indicates location of sample discussed in text of report

Figure 17: Principal Components Loadings Plot



## Advanced Chemical Fingerprinting Characteristics

From the results of the PCA, four "extreme" samples (samples at the outer boundaries of the scores plots) are examined to further identify product sources and possible sediment mixing. The samples that are further examined are:

YCT2NS3  
YCT2NC2  
YCT1NC1  
YCT4MS0

### YCT2NS3

The GC/FID chromatogram of this sample (Figure 18) is dominated by the presence of an unresolved complex mixture (UCM), or hump, in the lubricating oil range (approximately n-C<sub>20</sub> to n-C<sub>30</sub>). The PAH distribution profile (Figure 22) includes the lighter, petroleum derived PAHs. These include the two- and three-ring PAHs, the naphthalenes, fluorenes, and phenanthrenes. Other characteristics of petroleum derived PAHs are observed in the distribution profile. The distribution within the chrysene homologous series has been altered from the initial "bell" shape typical of petroleum, to one dominated by higher alkylation and declining concentration with declining alkylation. This alteration is due to physical processes described as weathering, which include volatilization, water dissolution, and hydrolysis, and biological processes described as biodegradation. In petroleum derived sources, such as crude oil, the PAHs typically comprise a substantially lower proportion of the TPH (less than 1 percent to 5 percent) than in combustion derived hydrocarbon products such as coal tars which are enriched in PAHs. PAHs in coal tars typically comprise as much as 50 percent of the TPH. In this sample total PAHs comprise 0.6 percent of the TPH. While this would imply that the sample is highly influenced by petroleum sources, impact from pyrogenic sources is indicated by the distribution of PAHs associated with pyrogenic sources.

### YCT2NC2

The GC/FID chromatogram of this sample (Figure 19) is also dominated by a UCM in the lubricating oil range. The PAH distribution profile of this sample (Figure 23) is dominated by pyrogenic PAHs, specifically pyrene and benzo[b]fluoranthene. Lower molecular weight two- and three-ring PAHs are present at elevated levels (e.g., dibenzothiophenes) suggesting the presence of a diesel range petrogenic contaminant. This distribution displays characteristics similar to that of atmospheric dust mixed with highway runoff (Figures 12 and 13). The concentration of PAHs as a proportion of TPH is low (0.4%) indicating influence primarily by petrogenic sources.

## YCT1NC1

The GC/FID chromatogram of this sample (Figure 20) is dominated by resolved and unresolved hydrocarbons in the lubricating oil range. Resolved hydrocarbons are also observed in the diesel range (approximately  $n$ -C<sub>10</sub> to  $n$ -C<sub>20</sub>). The PAH distribution profile (Figure 24) exhibits two distinct characteristics. The distribution is dominated by pyrogenic derived PAHs, especially pyrene. The relative depletion of fluoranthene and relatively low PAH/TPH ratio (0.8%) separates this sample from other Station 1 samples. Differences in the samples from this station may be due to differences in source materials as well as a difference in the proportions in the samples from the same sources.

The distribution within several PAH homologous series indicates impact from petroleum sources. Comparison to patterns for fresh petroleum products, the patterns in the sample indicate that the contaminants have undergone significant weathering.

## YCT4MSO

The GC/FID chromatogram of this sample (Figure 21) is dominated by resolved and unresolved hydrocarbons in the lubricating oil range. The PAH distribution profile (Figure 25) is dominated by pyrogenic derived PAHs, especially fluoranthene, pyrene, and benzo(b)fluoranthene. The distribution within several homologous series, especially phenanthrene and chrysene, exhibit characteristics typical of pyrogenic derived sources. In coal tar the parent compound dominates each homologous series and concentration declines with greater alkylation. This sample has the highest percent of PAHs relative to TPH of the four samples discussed here (1.9%) which is more toward that observed in pyrogenic products. While the TPH of this sample is derived primarily from lubricating range petroleum, the PAHs are primarily derived from pyrogenic product sources such as coal tars/atmospheric deposition.



Figure 19: YCT2NC2 GC/FID Chromatogram

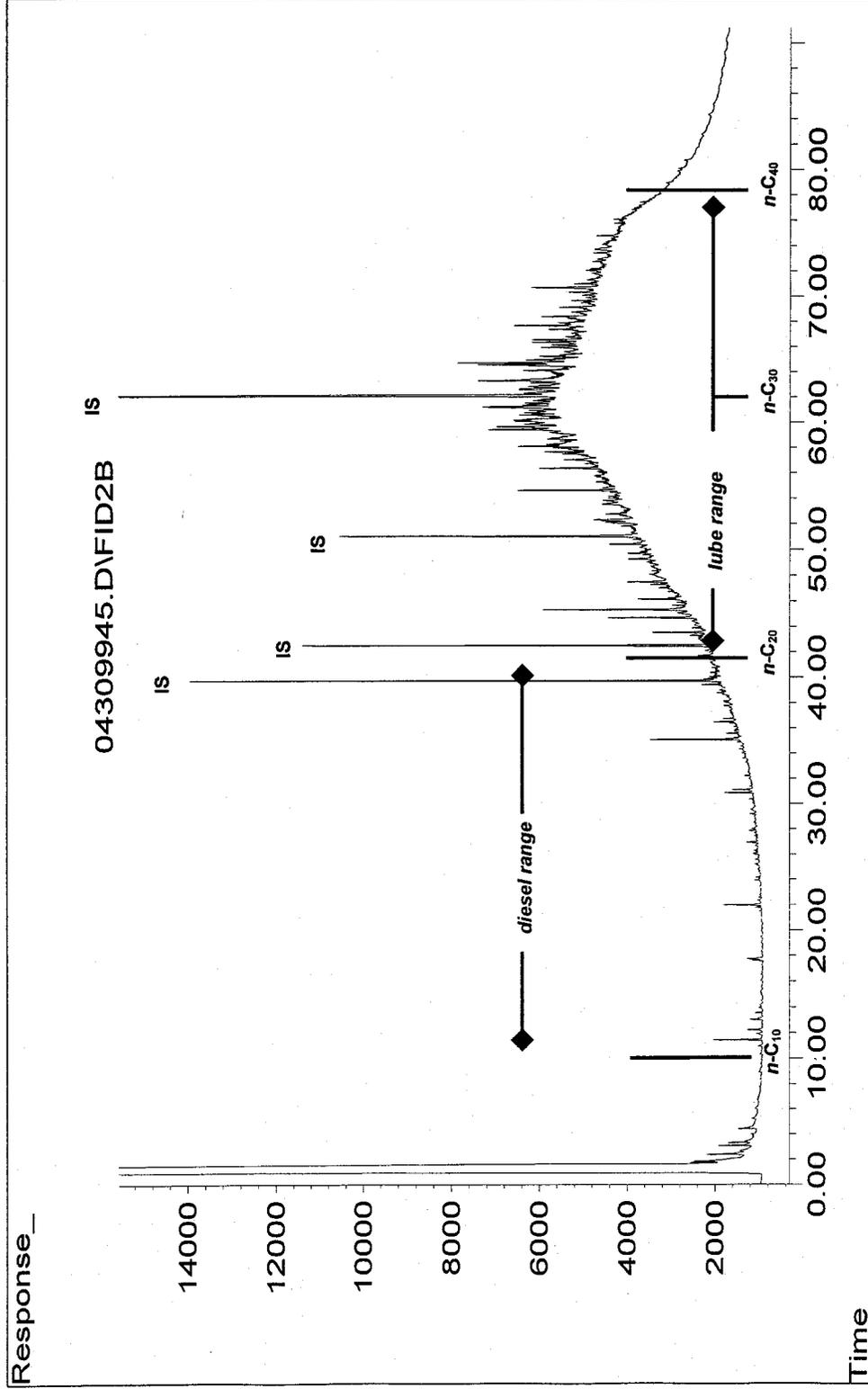


Figure 20: YCT1NC1 GC/FID Chromatogram

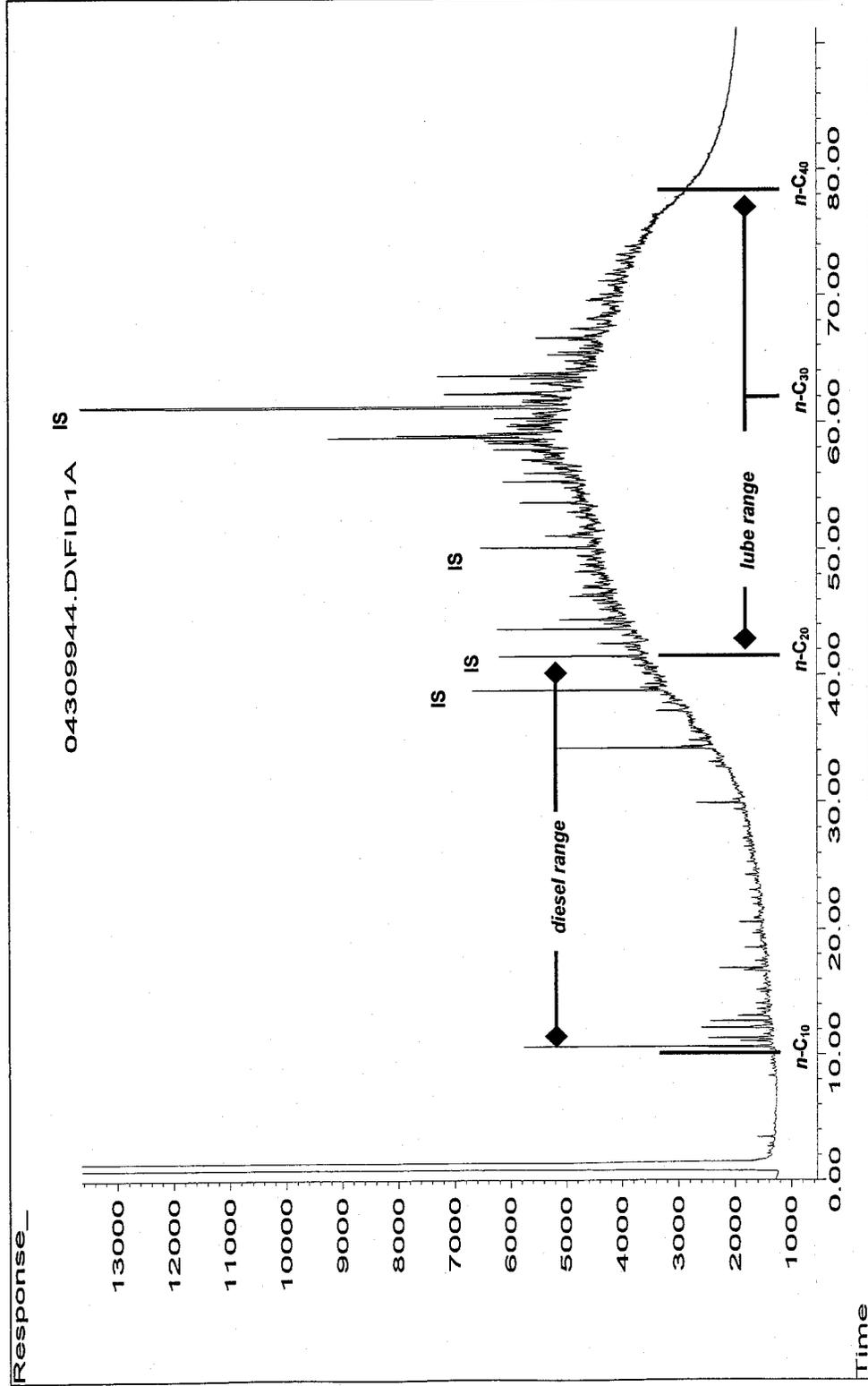


Figure 21: YCT6MS0 GC/FID Chromatogram

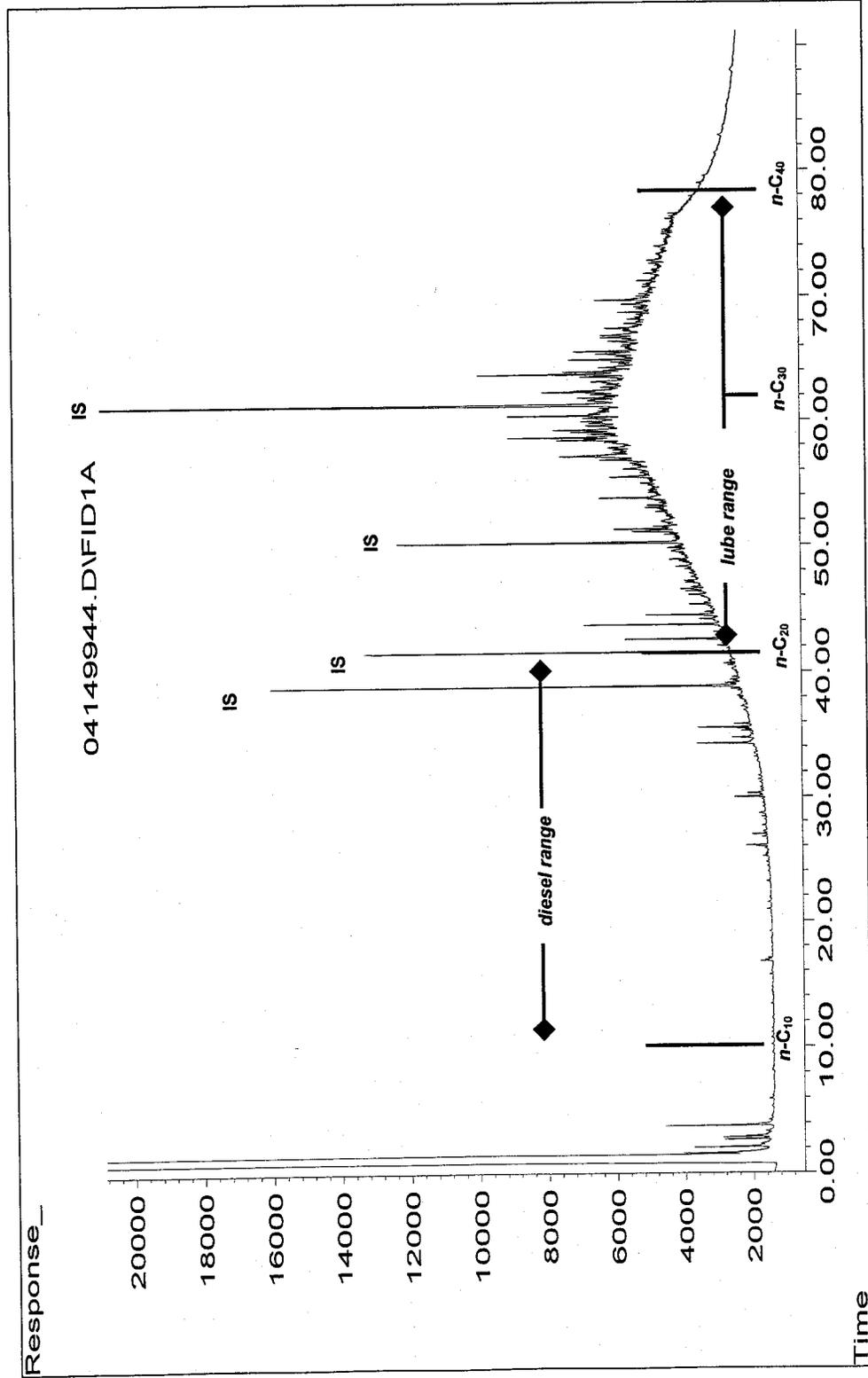


Figure 22: Distribution of LAB, PAH, and SHC – Sample YCT2NS3

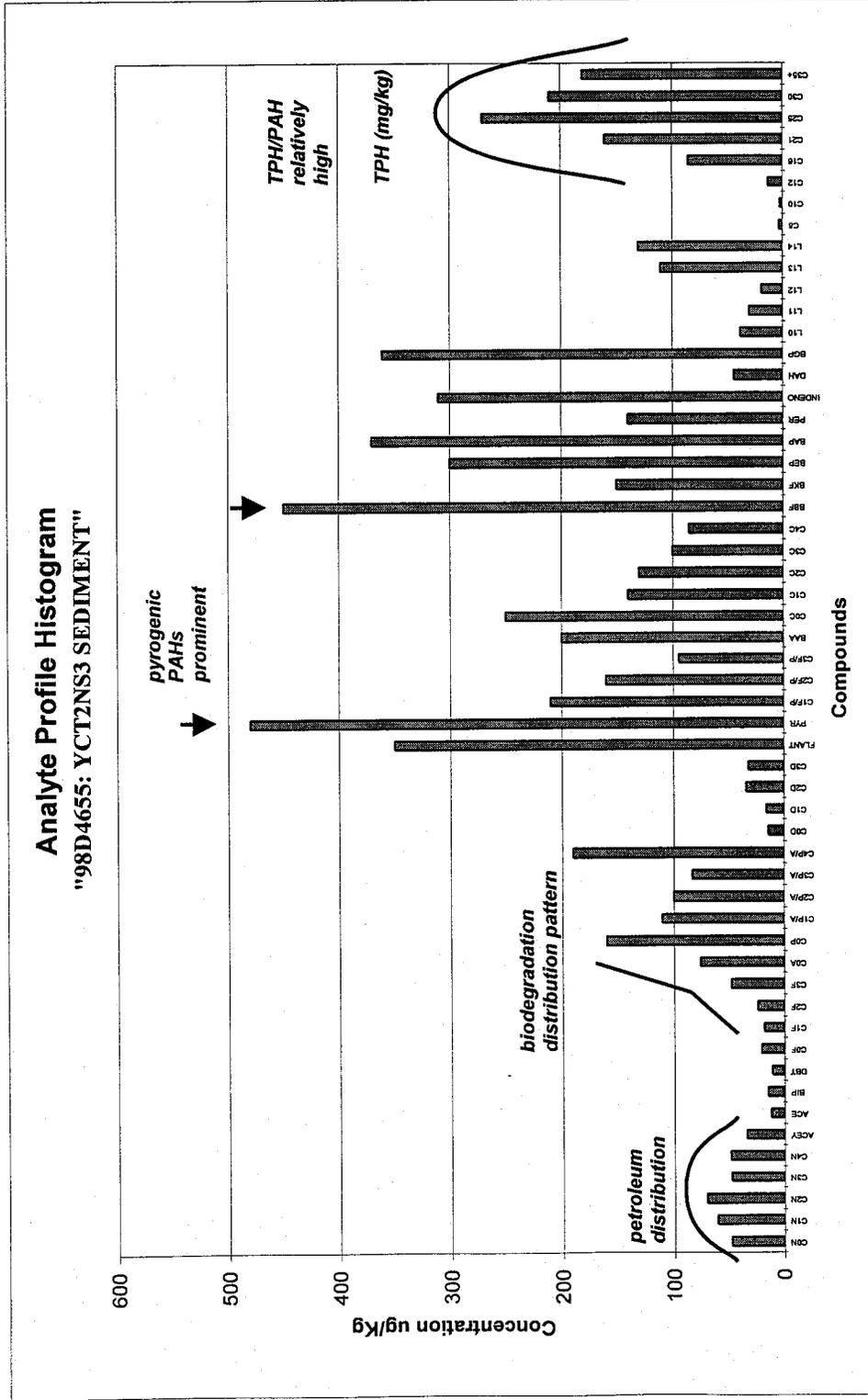


Figure 23: Distribution of LAB, PAH, and SHC – Sample YCT2NC2

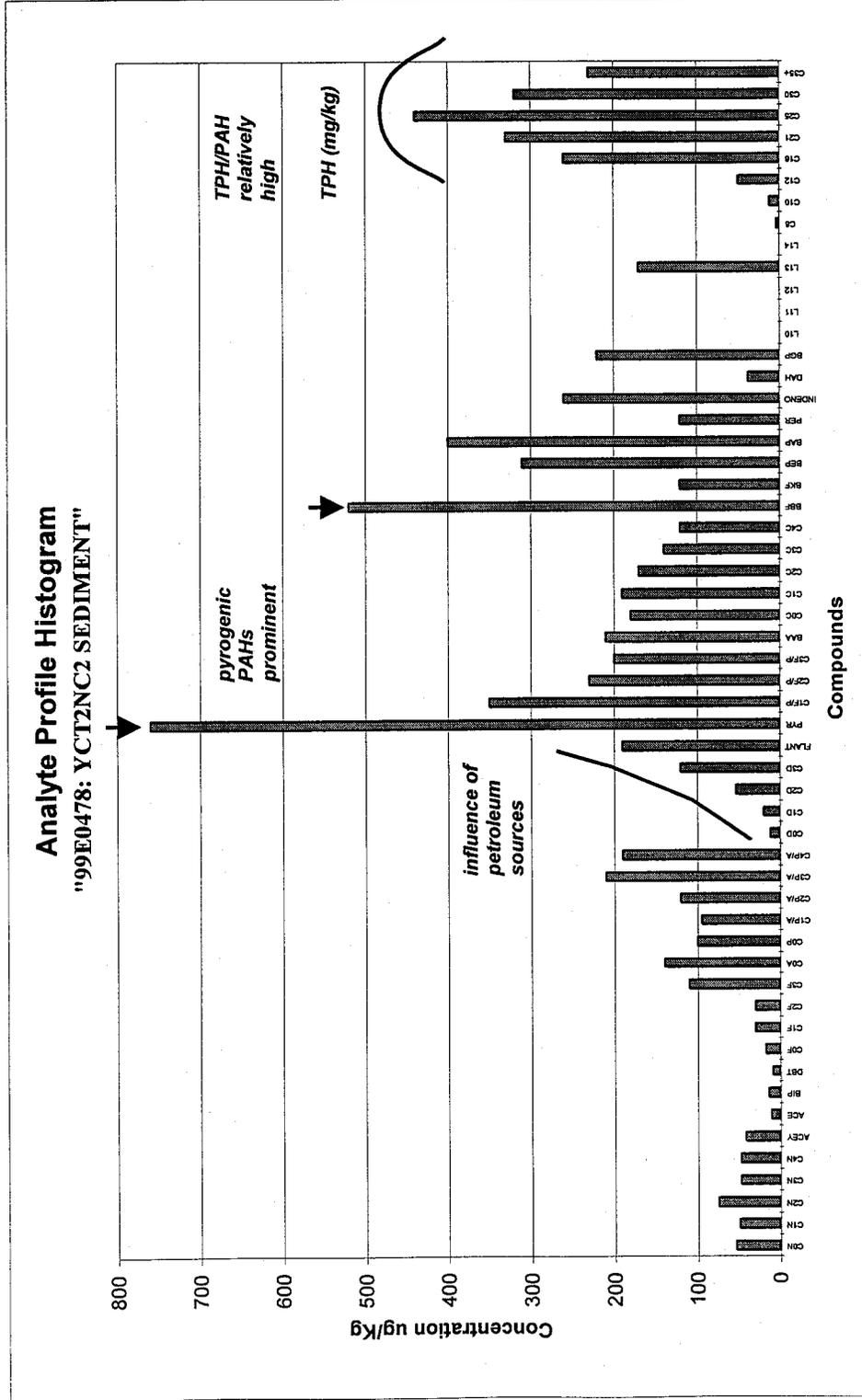


Figure 24: Distribution of LAB, PAH, and SHC – Sample YCT1NC1

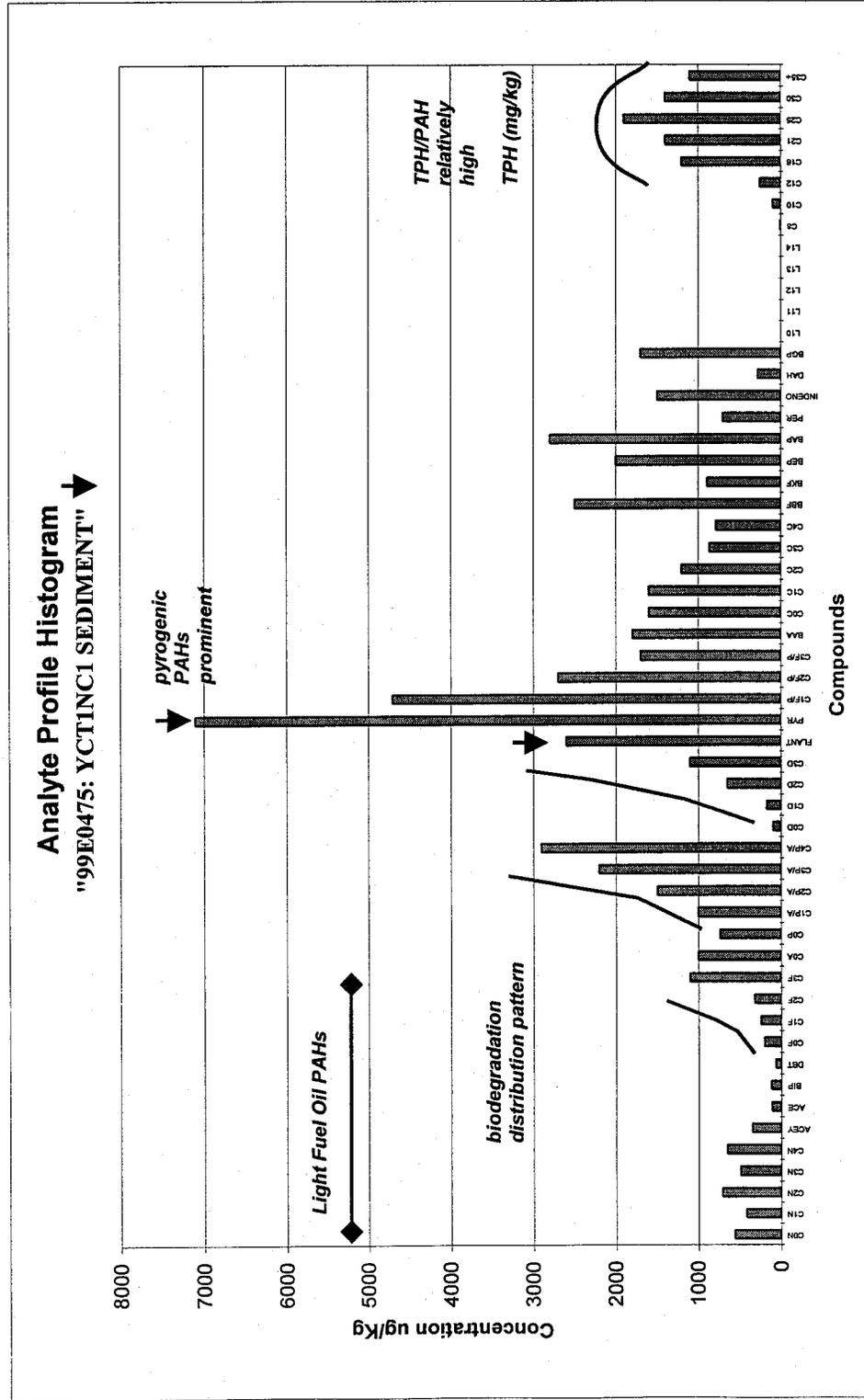
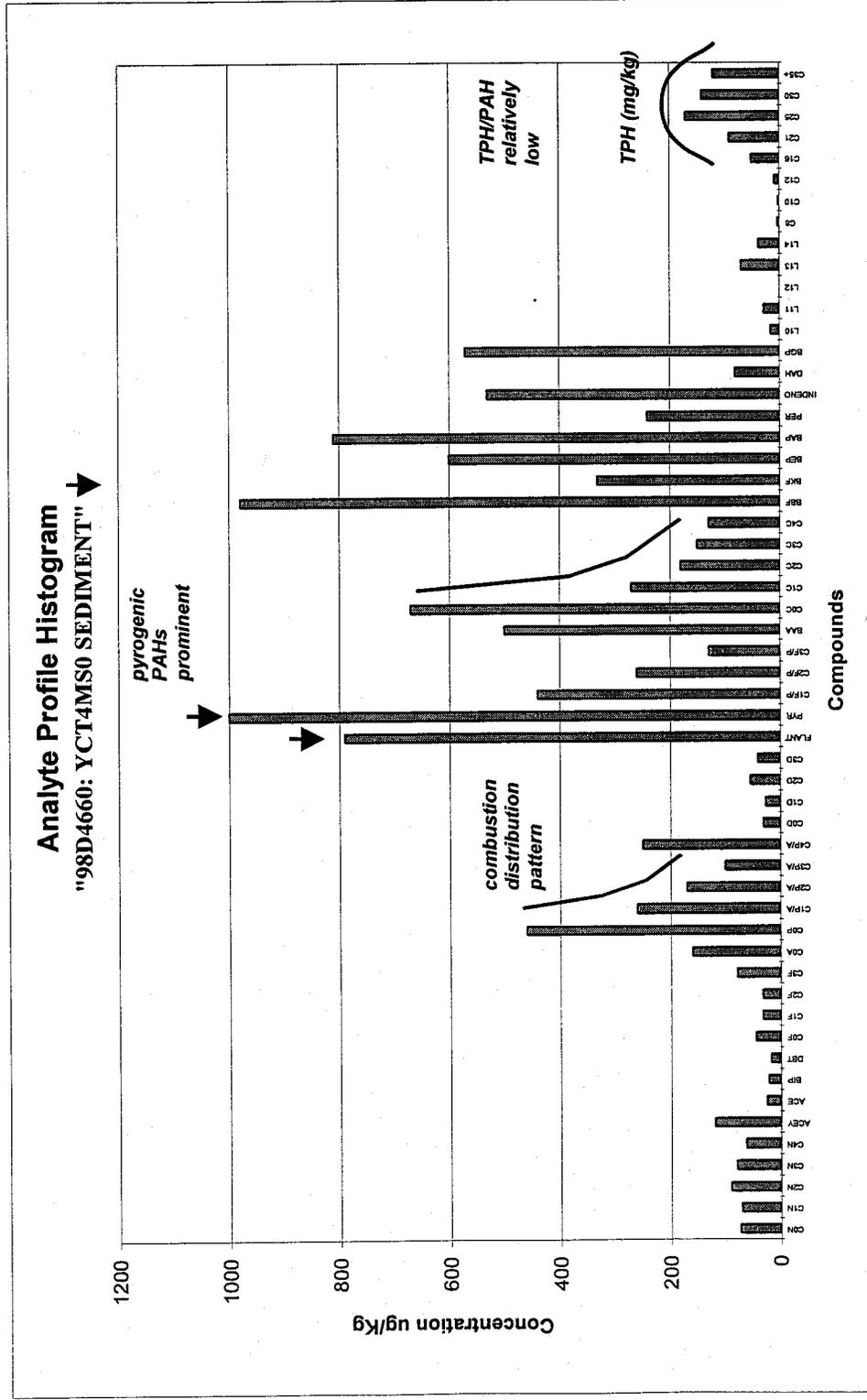


Figure 25: Distribution of LAB, PAH, and SHC – Sample YCT4MS0



## Polychlorinated Biphenyls (PCBs)

The analysis of PCB congeners and identification of Aroclor type (e.g., Aroclor 1242 versus Aroclor 1260), and the spatial distribution (horizontal and vertical sediment distributions) within Yosemite Creek provides important information concerning potential sources of these contaminants. Aroclors were used in a variety of industrial activities including electrical storage and transmission, and specialized foundry operations

Concentrations of PCBs in samples from the upper Yosemite Creek are higher than in samples from the lower creek. For example note concentration of PCBs in Station 1 (YCT1NC1) compared to Station 5 (YCT5SSO). The data suggests that a large historical input may have occurred at Station 1. Samples from locations near the naval facility (Station 6) had the next highest levels. Samples from Station 5, which are representative of the lower creek sediments, are in all cases higher than the Paradise Cove reference samples.

The currently available data, including the concentration distribution of PCBs in the samples collected in this study (Stations 1 to 5), does not suggest that Yosemite is the source of PCBs in samples analyzed from near the naval facility (Station 6). The high PCB concentrations and geographical distribution vertically and horizontally do suggest the possibility of multiple input sources of PCBs which will be examined in the Phase II study. Although concentrations of PCBs are higher in samples from Yosemite Creek than those from Islas Creek or Mission Creek, it should not be inferred that PCBs are being transported into San Francisco Bay from Yosemite Creek. Additional samples need to be collected and analyzed beyond Station 5 to further evaluate this issue.

Correlation of contaminant concentrations and distributions at Yosemite Creek with <sup>210</sup>Pb age dating in the Phase II study will provide critical data concerning dates of releases to the creek. Having age information will allow for potential sources to be eliminated as possibilities (e.g., if the source did not exist during a specified time interval) or to be implicated (e.g., identifying site use during certain time periods). Dating can also be correlated with recorded changes in the Creek inputs and process upgrades such as combined sewer outfall (CSO) treatment changes, ban of PCBs, etc.

Two main Aroclor types were identified in the samples collected from Yosemite Creek, Aroclor 1254 and 1260. Figure 27 is a plot of the concentrations of these Aroclors in the samples Yosemite Creek. It should be noted that the analytical method used to quantify Aroclors, which are mixture of many PCB congeners, may be biased generally high. This is because the effects of PCB degradation are not accounted for as well as the fact that, for the two Aroclors measured (Aroclor 1254 and Aroclor 1260), common congeners exist and these may be "double counted" by the method.

The line in Figure 27 is drawn as a 1:1 relationship. This line is useful for the visual identification of differences in the sample set. As noted above, concentrations of Aroclors in samples from Yosemite Creek are higher than those observed in reference sample. This indicates that inputs of PCBs have significantly impacted the creek. The

variations in the Aroclor distributions in the samples, both in type as well as geographically [especially vertically (sediments versus core)] indicates in the Figure indicates that there have been a variety of sources of PCBs to Yosemite Creek. The sources of these contaminants were not investigated in this study, however the Phase II study will examine potential sources such as CSOs, highway runoff, hot spot shoreline areas, and adjacent land runoff associated with specific present and historical land use activities.

Figure 28 is an expanded plot of the Aroclor concentrations plotted in Figure 27. The Station 6 samples located next to the naval facility are clearly different in distribution (relatively enriched in Aroclor 1260) than those from the creek. This is significant because it implies that Yosemite Creek sources are not related to the PCBs in samples from near the naval facility. The difference between the creek samples and those from near the naval facility is also detected in the PCA of the analytical results (Figure 29 and Figure 30).

Figure 26: Distribution of PCBs in Creek Sediments

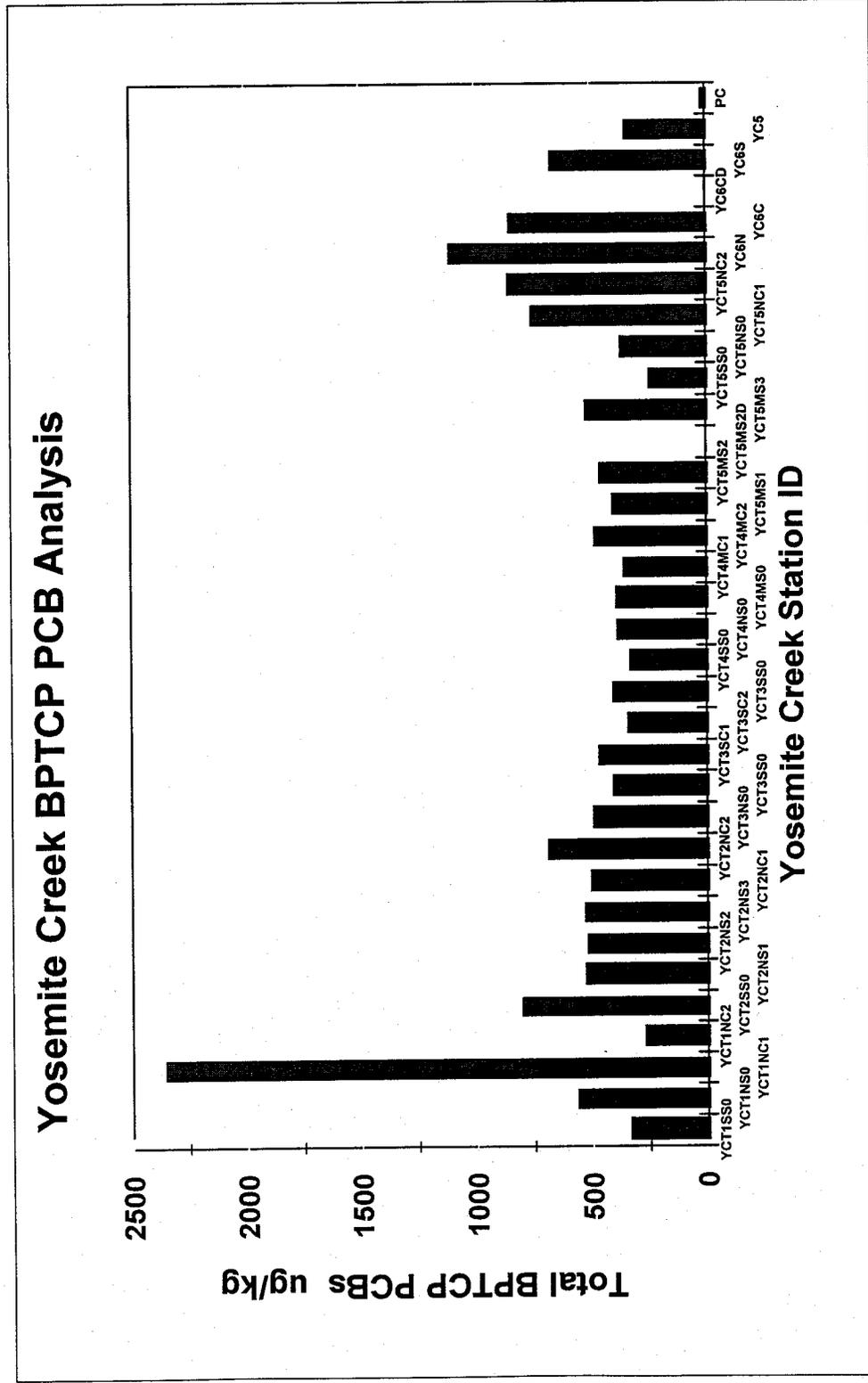


Figure 27: Plot of Concentrations of Two Aroclors

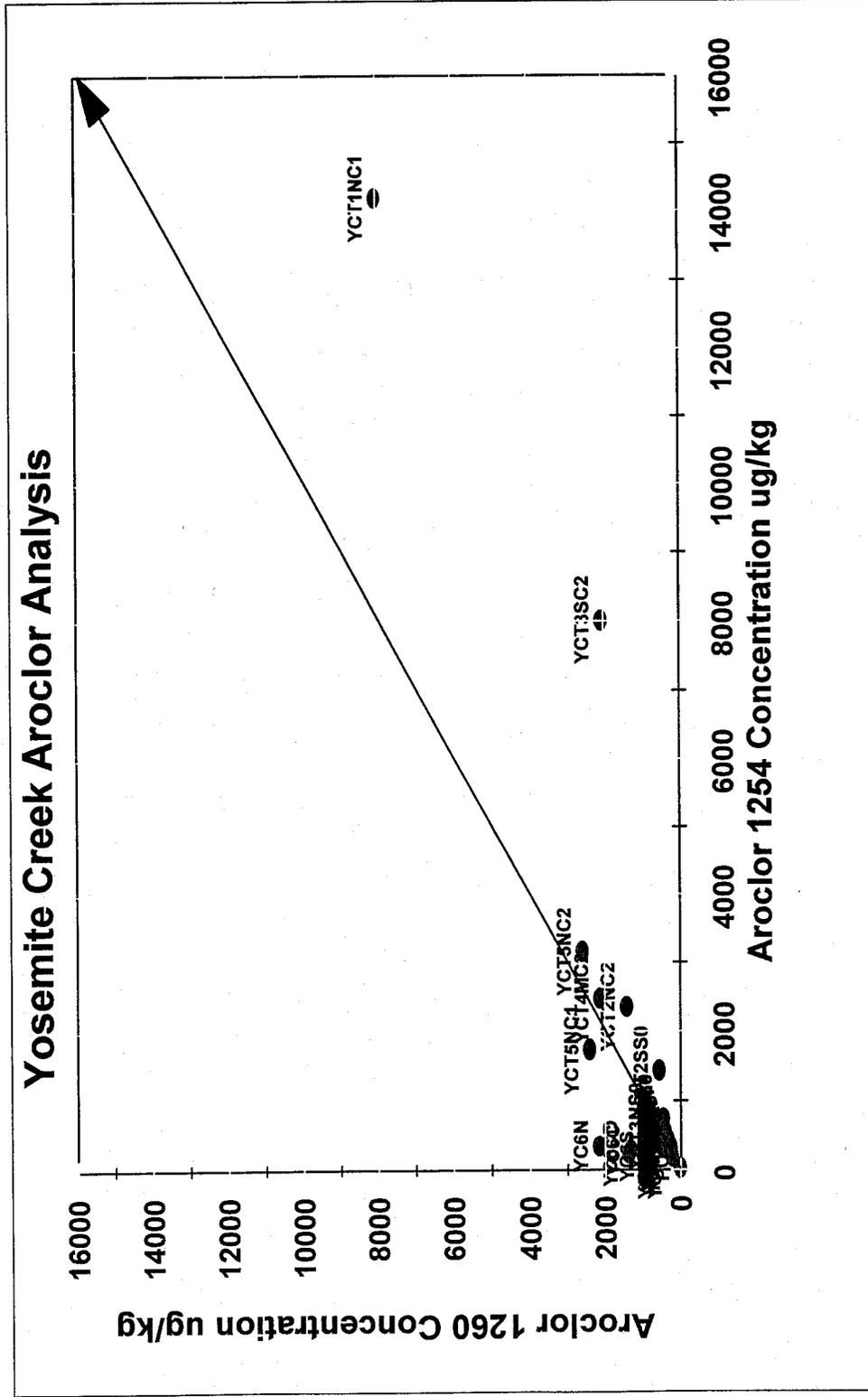


Figure 28: Expanded Plot of Concentrations of Two Aroclors

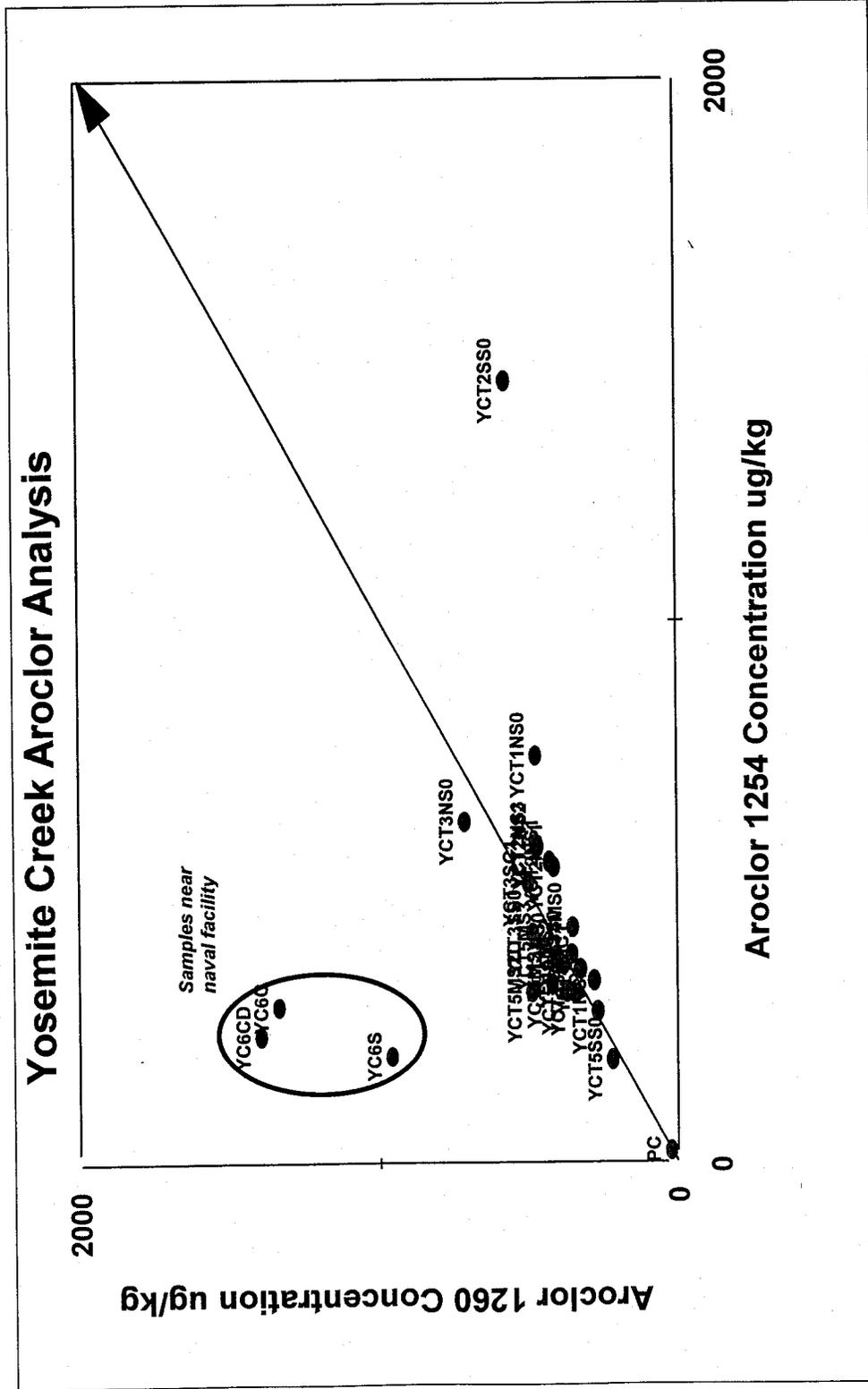




Figure 30: PCB Principal Components Loadings Plot

