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ENVIRONMENTAL EVALUATIONS FOR DEEPENING OF RICHMOND HARBOR AND SANTA FE CHANNELS

TASK 4: CHEMISTRY PROGRAM

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SUMMARY

Richmond, California is an important commercial port in San Francisco Bay. The Richmond Harbor waterways are currently maintained at a depth of -35 ft relative to mean lower low water (MLLW). The San Francisco District of the U.S. Army Corps of Engineers (USACE) plans to increase the depth of Richmond Harbor and Santa Fe Channels to -38 feet MLLW to accommodate deep-draft commercial vessels. This dredging project also includes widening the junction between the channels and adding a turning basin in Richmond Harbor Channel. The total volume of dredged material is expected to be approximately 1.4 million cubic yards. The options for disposal of the dredged material are aquatic disposal and upland disposal. The purpose of this study was to develop a database on chemical compounds in the dredged material to assist with determination of disposal methods and the need for additional testing. This purpose was accomplished through an extensive field sampling program followed by chemical analysis of samples.

Field sampling involved collection of core samples from Santa Fe and Richmond Harbor Channels. Cores were shipped to Battelle/Marine Sciences Laboratory, where they were subsampled for chemical analysis and/or archived by freezing. Samples that were analyzed included 49 bulk sediment samples from Richmond Harbor Channel, 6 bulk sediment samples from Santa Fe Channel, 3 interstitial water samples from Santa Fe Channel, and 3 elutriate samples from Santa Fe Channel. All sediment and water samples were analyzed for priority pollutants, including metals, organotins, base/neutral semivolatile organic compounds, chlorinated pesticides and PCBs, herbicide acids, and acidic phenols. Sediment samples were also analyzed for oil and grease and total organic carbon. Organophosphorus pesticides and dioxins and furans were measured in selected sediment samples from Richmond Harbor Channel and from both sediment and water samples from Santa Fe Channel.

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1.0 INTRODUCTION

1.1 OVERVIEW OF THE PROGRAM

The San Francisco District of the U.S. Army Corps of Engineers (USACE) is currently planning to deepen the navigation channels of Richmond Harbor and Santa Fe Channels in Richmond, California (Figures 1 and 2), to allow access to deep-draft vessels. For the purposes of this report, Richmond Harbor Channel includes the Harbor Entrance Channel, Potrero Channel, and the Inner Harbor Channel. This work is consistent with USACE dredging regulations in 33#CFR Parts 208 and 220-227, the Clean Water Act 404(b)(1) guidelines, and the Ocean Dumping Act. According to this plan, both channels would be deepened to -38 ft mean lower low water (MLLW) from the presently authorized depth of -35 ft MLLW.

Battelle/Marine Sciences Laboratory (MSL) in Sequim, Washington, is assisting the USACE with sedimentary and chemical evaluations in Richmond related to determination of dredged-material disposal options. The two main options under consideration are aquatic disposal and upland disposal. The first step in making decisions regarding disposal options was to develop a chemical database on compounds in the sediments. The purpose of this MSL program was to develop that database for the USACE.

To date, the program has been divided into four tasks, as follows:

Task 1: Background Data Collection
Task 2: Program Planning
Task 3: Preliminary Cruise Preparations
Task 4: Chemistry Program

Task 1 entailed identification of sampling sites and preparation of a list of detection limits for analytes that might be required for analysis in the program. Program Planning was conducted under Task 2 and entailed preparation of several plans, including a field sampling plan, a work plan, a safety plan, and a quality assurance (QA) plan. Task 3 encompassed early preparation for the field sampling that had to be started prior to initiation of Task 4.

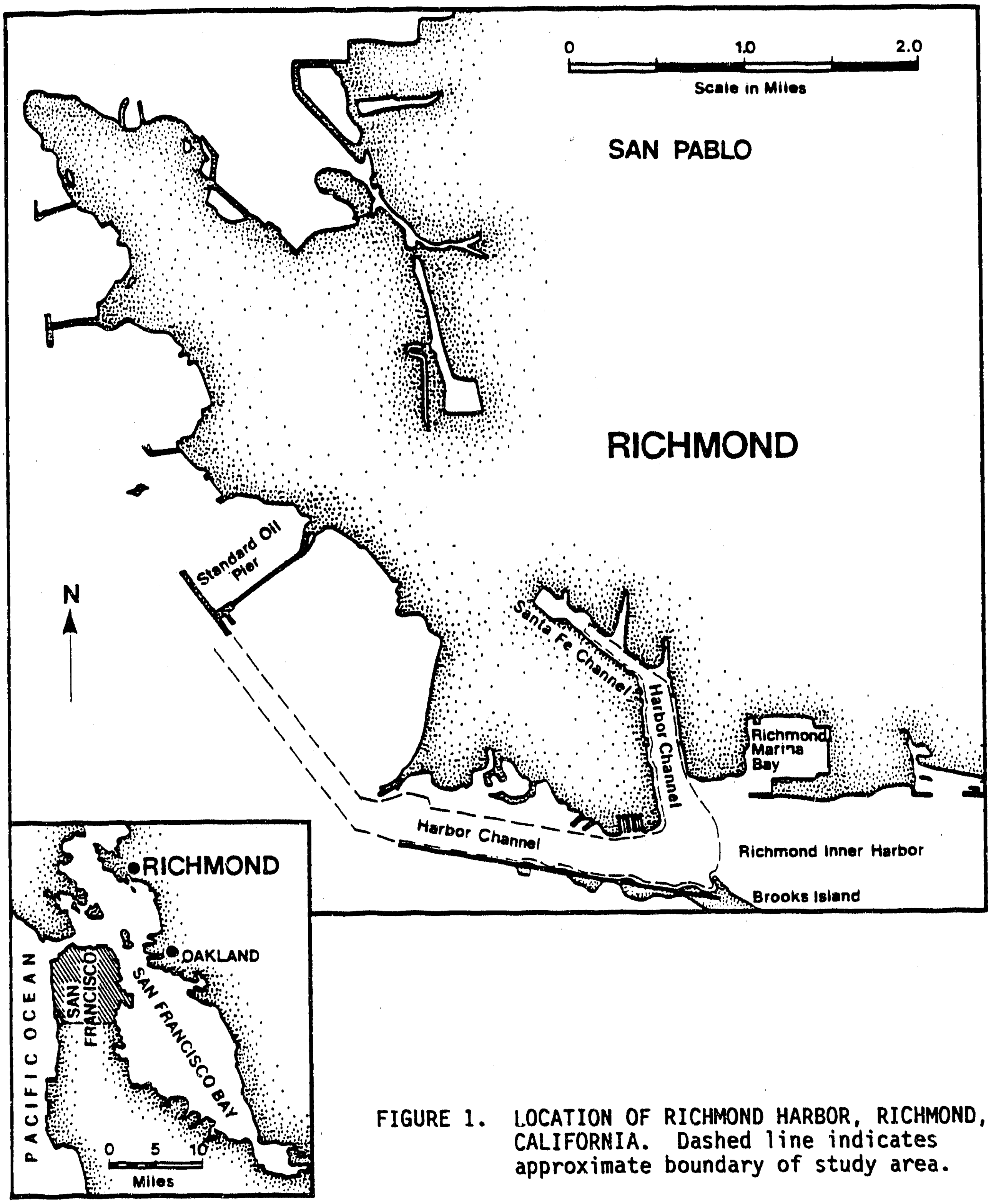

FIGURE 1. LOCATION OF RICHMOND HARBOR, RICHMOND, CALIFORNIA. Dashed line indicates approximate boundary of study area.

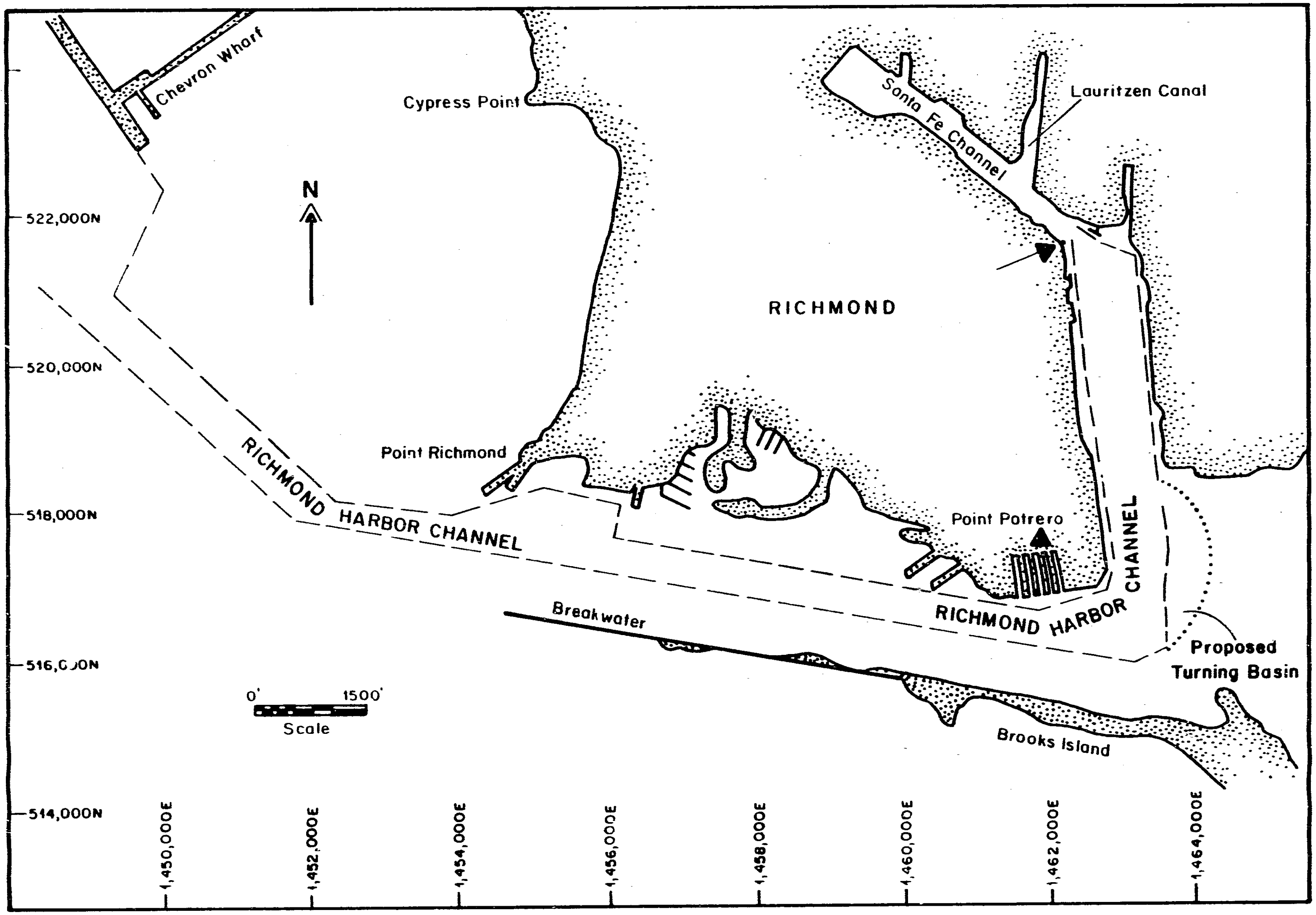

FIGURE 2. LOCATION OF SANTA FE AND RICHMOND HARBOR CHANNELS. Arrow = widening area. Closed triangle = staging area.

This report covers Task 4 of the program "Environmental Evaluations for Deepening of Richmond Harbor and Santa Fe Channels."

1.2 OBJECTIVES OF THE CHEMISTRY PROGRAM

The objectives of the Chemistry Program (Task 4) were as follows:

1. Field Sampling: To collect field samples appropriate for characterization of the spatial and vertical distribution of contaminants in the sediments and for analysis of elutriate samples. Samples were collected for both analysis and archiving.

2. Laboratory Preparation: To geologically characterize selected cores; to prepare bulk sediment, elutriate water, and interstitial water samples for analytical chemistry from the core samples to be analyzed; and to archive by freezing the remainder of analyzed cores and whole cores.

3. Analytical Chemistry: To analyze the sediment, elutriate water, and interstitial water samples for numerous compounds including base/neutral semivolatile organic compounds, chlorinated and organophosphorus pesticides, polychlorinated biphenyls (PCBs), herbicide acids and phenols, metals, butyltins, oil and grease, and total organic carbon. In addition, organophosphorus pesticides and dioxins and furans were analyzed for selected sites.

4. Reporting: To present the results for field sampling, laboratory preparation, and analytical chemistry. At the request of the USACE, no data analysis has been provided.

1.3 SITE BACKGROUND

Richmond Harbor is located on the eastern shore of San Francisco Bay, north of Oakland and northeast across the bay from San Francisco (Figure 1). Most of the commerce and industry in Richmond Harbor is in petroleum, chemical products, and bulk cargo handling. Development of the harbor began in the early 1930s, with major development occurring in the early 1940s, when four World War II shipyards and a fabrication yard were built on much of the land adjacent to Santa Fe and Richmond Harbor Channels. Since the end of the wartime ship-building boom, the sites adjacent to the channels have housed a succession of industrial operations.

2.0 FIELD SAMPLING

2.1 INTRODUCTION AND OBJECTIVES

The goal of the field sampling was to collect samples appropriate for determination of the horizontal and vertical distribution of chemicals in the sediments. Specific objectives were as follows:

1. To collect sediment cores from 42 sites in Richmond Harbor Channel to project depth of -38 ft MLLW plus 1 ft of overdraft plus 1 ft of exposed sediment (Figure 3). Sediment from 26 of these cores was to undergo bulk sediment analysis only; sediment from the remaining 16 was to be archived for possible future analysis.

2. To collect five cores from the proposed turning basin in Richmond Harbor Channel and one core from the proposed widening area at the junction of Richmond Harbor and Santa Fe Channels (Figure 3). These areas have not been previously dredged, and the cores from these areas were expected to be 20 to 35 ft long. Samples prepared from these sediment cores will undergo bulk sediment analyses only.

3. To collect sediment cores from 60 sites in Santa Fe Channel to project depth of -38 ft plus 1 ft of overdraft and 1 ft of exposed sediment to a total depth of -40 ft MLLW. The 60 sites, divided into 18 sites in Reach A, 18 in Reach B, and 24 in Reach C (Figure 4), were chosen by USACE's Waterways Experiment Station (WES) in Vicksburg, Mississippi. Following a compositing scheme designed by WES, sediments from these cores were to undergo bulk sediment, interstitial water, and elutriate chemistry analyses.

4. To collect 10 gallons of water from the center of Santa Fe Channel for use in elutriate-sample preparation.

Field sampling operations were initiated on April 3, 1989, and completed on April 12, 1989. Of the 108 sediment stations planned for sampling, 96 sites were actually sampled (Figures 3 and 4). Twelve sediment samples in Santa Fe Channel were not collected because the sediment surface was already below the project depth (-38 ft MLLW plus 1 ft overdraft and 1 ft exposed surface) (Figure 4). The 48 sampling sites in Richmond Harbor Channel (Figure 3) were chosen by USACE and the MSL following completion of Task 1 (Background Data Collection).

The 42 cores from Richmond Harbor Channel (Objective 1) and the 60 from Santa Fe Channel (Objective 3) will be referred to as short cores, as most

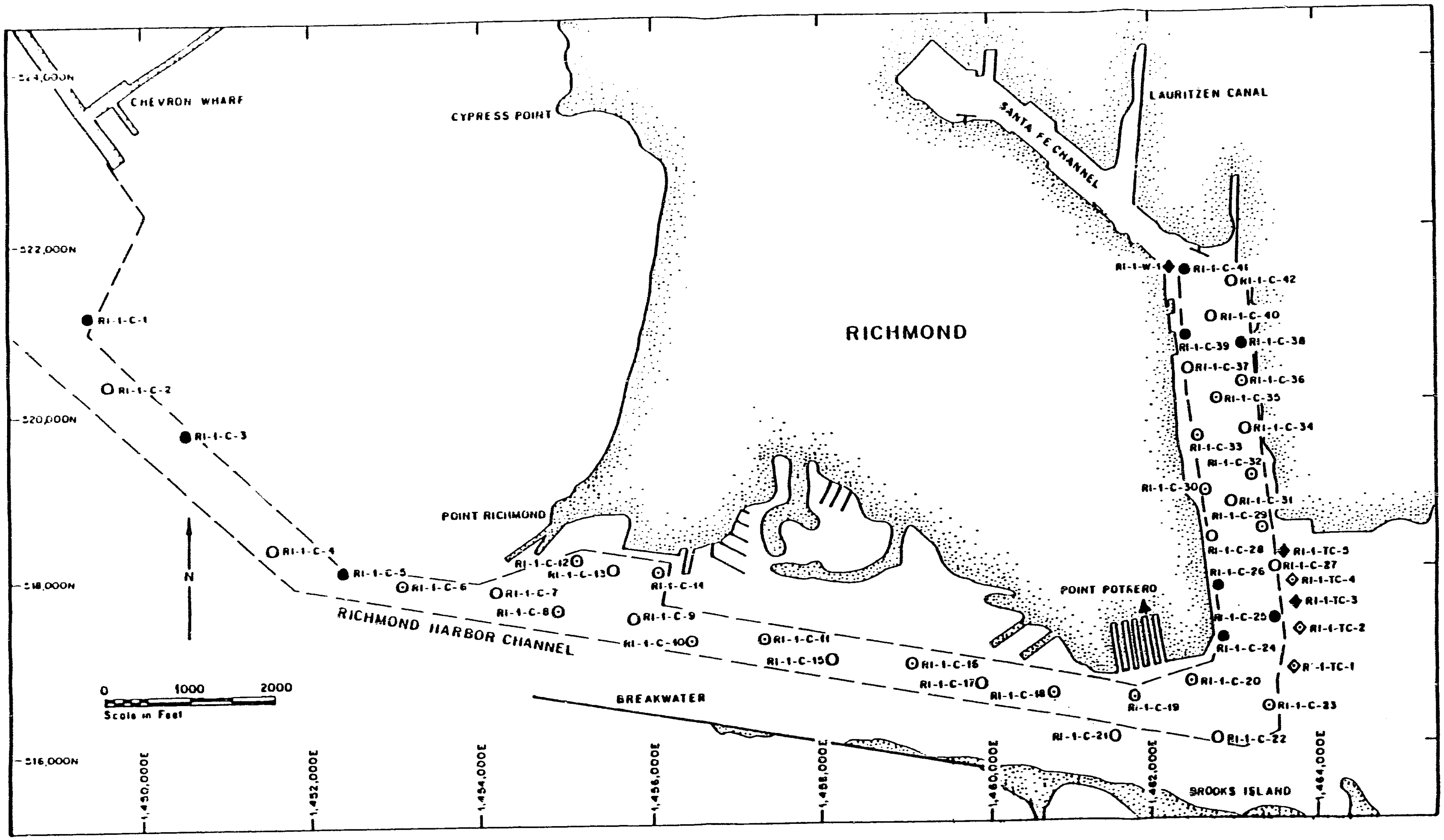

FIGURE 3. LOCATION OF SAMPLING STATIONS IN RICHMOND HARBOR CHANNEL (diamond=long cores, ◆=analyzed for "A" group analytes, ◇=analyzed for "B" group analytes; circle=short cores, ●=analyzed for "A" group analytes (see text), ⊙=analyzed for "B" group analytes; ○=archived whole; ▲=staging area.

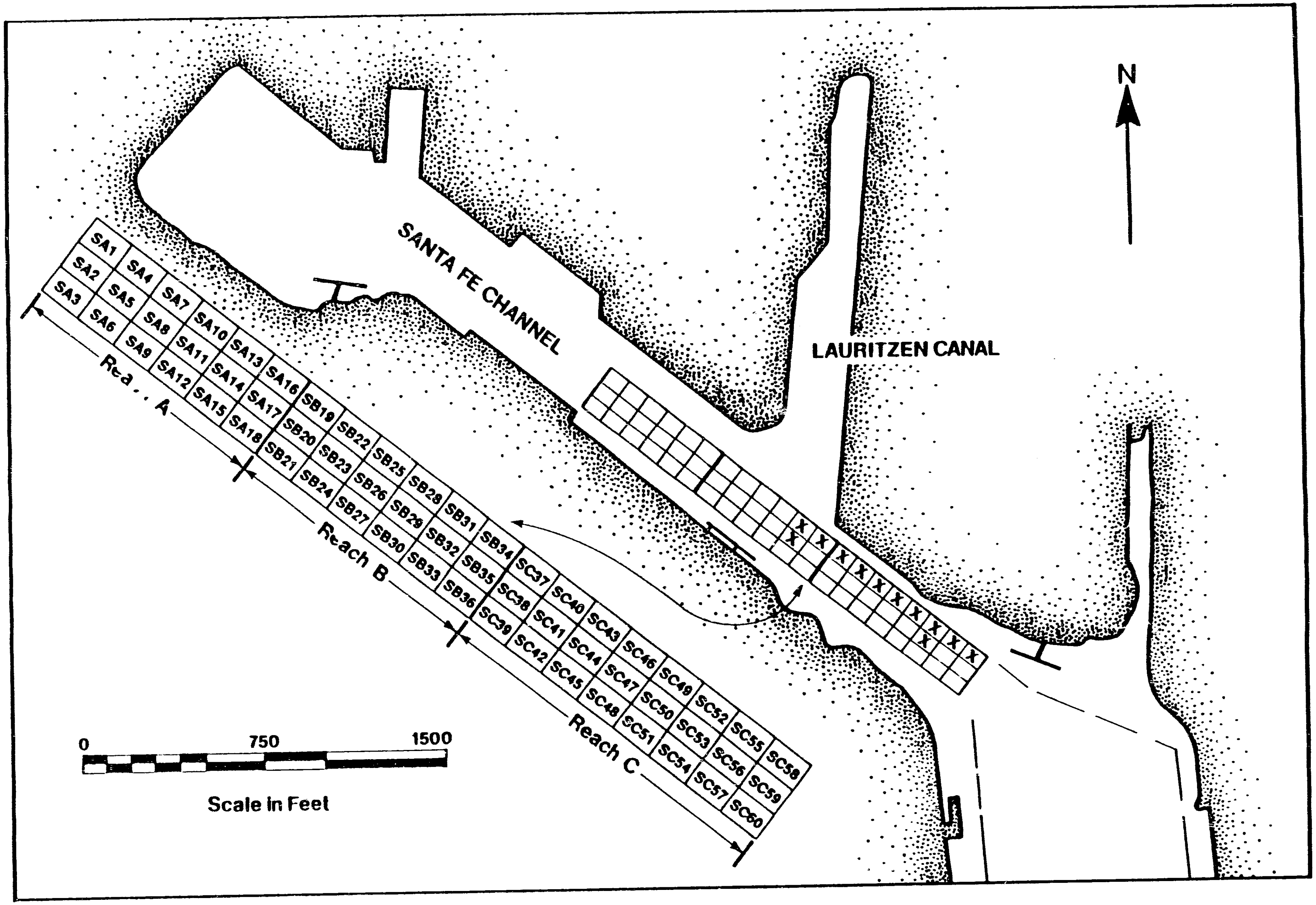

FIGURE 4. LOCATION OF SAMPLING STATIONS IN SANTA FE CHANNEL. Stations marked with X were not sampled.

were expected to be less than 10 ft long. The six cores from the undredged areas (Objective 2) are referred to as long cores. In Richmond Harbor Channel, 13 stations were successfully sampled with the gravity corer. The six long-core stations (Stations RI-1-W-1 and RI-1-TC-1 through RI-1-TC-5) were sampled with the vibratory corer, as were the remaining 29 short-core stations. In Santa Fe Channel, 48 stations were successfully cored with the vibratory corer, and 12 sites were not attempted because the sediment surface was already below project depth. Approximately 10 gallons of water was collected from the center of Santa Fe Channel for laboratory preparation of elutriate samples. Sample collection information is summarized in Table 1.

2.2 VESSELS AND NAVIGATION

A total of four vessels were used to complete the field sampling: two tugboats, a derrick barge, and an inflatable boat. Different vessels were required for the operation of each of the two types of core samplers, a gravity corer and vibratory corer. The core samplers are described in the Section 2.3.1. The 40-ft tugboat California Eagle, operated by Tom Decker of Slackwater Towboat Company of Richmond, California, was used for gravity coring. Vibratory-coring operations took place aboard a derrick barge provided by Manson Pacific Construction and Engineering Company of Richmond. The derrick barge, DB-17, was a 112 x 52-ft platform with a 130-ft crane. The barge was maneuvered by the tugboat Bearcat, operated by skipper Joe Wirth and Bill Hammond of Westar Marine Services.

Navigation, or positioning on the sampling sites, was provided by a team of two licensed surveyors from Land and Sea Surveys of Ventura, California. The fourth vessel, a small inflatable boat, was operated by one surveyor, while the second surveyor worked from a survey control point on shore. Sampling sites were located using a Geodometer laser/range azimuth positioning system and were marked by a retrievable buoy. The surveyors recorded the actual water depth at the station, then applied a tidal correction for the time to obtain a corrected depth relative to MLLW. Portable radios were used to communicate information between surveyors, scientists, and vessel crews. If the corrected depth at the sampling station was too deep to collect

TABLE 1. Sample Collection Information for Santa Fe and Richmond Harbor Channels

Station	California State Zone III Coordinates East (X)	North (Y)	Date Sampled	Start Time	Corer Type	Corrected Depth (MLLW)	Required Core (FT)	Collected Core (FT)	Length Upper (FT)	Length Lower (FT)	Comments
Short Cores: Richmond Harbor											
RI-1-C-1	1,449,413	521,122	5 APR	10:50	GRAVITY	-34.7	5.3	6.3	4.3	2.0	
RI-1-C-2	1,449,601	520,332	5 APR	12:05	GRAVITY	-36.7	3.3	4.7	2.3	2.4	
RI-1-C-3	1,450,533	519,762	10 APR	09:06	VIBRATORY	-33.8	6.2	7.2	5.2	2.0	
RI-1-C-4	1,451,525	518,371	5 APR	11:30	GRAVITY	-36.1	3.9	5.0	2.9	2.1	
RI-1-C-5	1,452,380	518,112	5 APR	12:40	GRAVITY	-35.8	4.2	6.0	3.2	2.8	
RI-1-C-6	1,453,063	517,915	10 APR	09:44	VIBRATORY	-32.0	8.0	>8.0	7.0	1.0	3 Attempts
RI-1-C-7	1,454,126	517,824	10 APR	10:39	VIBRATORY	-30.7	9.3	8.3	8.3	----	Archive core: no lower section
RI-1-C-8	1,454,907	517,589	5 APR	15:59	GRAVITY	-34.0	6.0	6.2	5.0	1.2	
RI-1-C-9	1,455,788	517,500	5 APR	16:15	GRAVITY	-34.2	5.8	6.5	4.8	1.7	
RI-1-C-10	1,456,433	517,248	5 APR	16:21	GRAVITY	-34.4	5.6	6.0	4.6	1.4	
RI-1-C-11	1,457,319	517,257	6 APR	08:49	GRAVITY	-34.0	6.0	7.0	5.0	2.0	
RI-1-C-12	1,455,139	518,190	5 APR	14:53	GRAVITY	-33.1	6.9	7.3	5.9	1.4	
RI-1-C-13	1,455,577	518,087	5 APR	14:39	GRAVITY	-32.7	7.3	6.4*	6.0	0.4	
RI-1-C-14	1,456,101	518,034	5 APR	15:22	GRAVITY	-33.5	6.5	6.3*	5.5	0.8	Middle sediment lost: analyze lower
RI-1-C-15	1,458,126	517,006	6 APR	08:30	GRAVITY	-36.4	3.6	4.0	2.6	1.4	
RI-1-C-16	1,459,064	516,945	10 APR	11:12	VIBRATORY	-31.6	8.4	7.7*	7.4	0.3	2 attempts with gravity core 4/6
RI-1-C-17	1,459,933	516,752	10 APR	12:02	VIBRATORY	-33.6	6.4	5.6*	5.4	----	2nd attempt; 2 gravity core tries 4/5
RI-1-C-18	1,460,752	516,595	10 APR	13:00	VIBRATORY	-33.4	6.6	6.0*	5.3	0.7	2nd attempt; 1 gravity core try 4/5
RI-1-C-19	1,461,753	516,529	5 APR	17:50	GRAVITY	-35.5	4.5	4.8	3.5	1.3	1st 2 attempts too short
RI-1-C-20	1,462,462	516,701	10 APR	13:42	VIBRATORY	-34.7	5.3	6.1	4.3	2.8	1 gravity corer attempt 4/5
RI-1-C-21	1,461,516	516,074	10 APR	13:22	VIBRATORY	-34.2	5.8	5.5*	4.8	0.7	1 gravity corer attempt 4/5
RI-1-C-22	1,462,784	516,018	10 APR	14:03	VIBRATORY	-34.3	5.7	8.5	4.7	3.8	1 gravity corer attempt 4/5
RI-1-C-23	1,463,294	516,421	10 APR	14:19	VIBRATORY	-31.2	8.8	10.7	7.8	2.9	
RI-1-C-24	1,462,866	517,209	10 APR	14:37	VIBRATORY	-34.3	5.7	7.6	4.7	2.9	
RI-1-C-25	1,463,473	517,426	9 APR	16:04	VIBRATORY	-34.0	6.0	6.0	5.0	1.0	
RI-1-C-26	1,462,787	517,807	10 APR	14:52	VIBRATORY	-33.6	6.4	6.4	5.4	1.0	

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* and ** -- See text for explanation of results.

TABLE 1. (continued)

Station	California State Zone III Coordinates East (X)	California State Zone III Coordinates North (Y)	Date Sampled	Start Time	Corer Type	Corrected Depth (MLLW)	Required Core (ft)	Collected Core (ft)	Length Upper (FT)	Length Lower (FT)	Comments
Short Cores: Richmond Harbor (continued)											
RI-1-C-27	1,463,492	518,015	9 APR	15:44	VIBRATORY	-35.0	5.0	4.8*	4.0	0.8	
RI-1-C-28	1,462,712	518,361	10 APR	15:15	VIBRATORY	-34.1	5.9	5.4*	4.9	0.5	
RI-1-C-29	1,463,334	518,493	9 APR	15:20	VIBRATORY	-34.2	5.8	6.5	4.8	1.7	
RI-1-C-30	1,462,644	518,942	10 APR	15:48	VIBRATORY	-33.6	6.3	6.2*	5.3	0.8	
RI-1-C-31	1,462,965	518,810	10 APR	15:30	VIBRATORY	-34.4	5.6	7.2	4.6	2.6	
RI-1-C-32	1,463,212	519,097	9 APR	15:50	VIBRATORY	-35.4	4.6	7.0	3.6	3.4	
RI-1-C-33	1,462,560	519,576	10 APR	16:10	VIBRATORY	-33.6	6.4	6.1	5.4	0.7	
RI-1-C-34	1,463,157	519,634	9 APR	14:40	VIBRATORY	-37.1	2.9	5.0	1.9	3.1	
RI-1-C-35	1,462,605	520,010	10 APR	16:29	VIBRATORY	-35.5	4.5	7.5	3.5	4.0	
RI-1-C-36	1,463,138	520,209	9 APR	14:25	VIBRATORY	-35.4	4.6	6.3	3.6	2.7	
RI-1-C-37	1,462,460	520,379	10 APR	16:46	VIBRATORY	-36.9	3.1	4.6	2.1	2.5	
RI-1-C-38	1,463,116	520,636	9 APR	13:54	VIBRATORY	-36.1	3.9	6.6	2.9	3.7	2nd attempt
RI-1-C-39	1,462,418	520,728	10 APR	17:00	VIBRATORY	-33.8	6.2	6.2	5.2	1.0	
RI-1-C-40	1,462,743	520,946	10 APR	17:10	VIBRATORY	-37.0	3.0	3.1	2.0	1.1	
RI-1-C-41	1,462,403	521,508	10 APR	17:32	VIBRATORY	-35.3	4.7	6.3	3.7	2.6	
RI-1-C-42	1,463,032	521,346	9 APR	13:28	VIBRATORY	-34.1	5.9	7.9	4.9	3.0	2nd attempt
Short Cores: Santa Fe Channel											
SA-1	1,460,913	522,916	7 APR	13:16	VIBRATORY	-36.0	4.0	>4.0	3.0	1.0	2 gravity corer attempts 4/6
SA-2	1,460,870	522,865	7 APR	12:52	VIBRATORY	-37.3	2.7	>7.0	LOST	LOST	Archived -40 to -44 ft section
SA-2 REP 2	1,460,870	522,865	7 APR	13:40	VIBRATORY	-37.3	2.7	>4.0	1.7	1.0	2 gravity corer attempts 4/6
SA-3	1,460,827	522,814	9 APR	08:40	VIBRATORY	-36.7	3.3	>4.0	2.3	1.0	2 gravity corer attempts 4/6
SA-4	1,460,990	522,851	7 APR	14:09	VIBRATORY	-37.1	2.9	>4.0	1.9	1.0	
SA-5	1,460,946	522,800	7 APR	14:22	VIBRATORY	-37.2	2.8	2.5*	1.8	0.7	
SA-6	1,460,903	522,749	9 APR	08:54	VIBRATORY	-36.2	3.8	>4.0	2.8	1.0	

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* and ** -- See text for explanation of results.

TABLE 1. (continued)

Station	California State Zone III Coordinates East (X)	North (Y)	Date Sampled	Start Time	Corer Type	Corrected Depth (MLLW)	Required Core (ft)	Collected Core (ft)	Length Upper (ft)	Length Lower (FT)	Comments
Short Cores: Santa Fe Channel (continued)											
SA-7	1,461,066	522,787	7 APR	15:55	VIBRATORY	-38.5	1.5	>4.0	0.5	1.0	
SA-8	1,461,022	522,736	7 APR	15:25	VIBRATORY	-37.5	2.5	>4.0	1.5	1.0	
SA-9	1,460,979	522,684	9 APR	09:25	VIBRATORY	-35.7	4.3	>4.3	3.3	1.0	
SA-10	1,461,142	522,722	7 APR	16:25	VIBRATORY	-38.7	1.3	>2.0	0.3	1.0	
SA-11	1,461,099	522.671	7 APR	16:13	VIBRATORY	-37.9	2.1	>4.0	1.1	1.0	
SA-12	1,461,055	522,620	9 APR	09:43	VIBRATORY	-35.7	4.3	>4.3	3.3	1.0	
SA-13	1,461,218	522,657	7 APR	17:15	VIBRATORY	-36.1	3.9	>4.0	2.9	1.0	
SA-14	1,461,175	522,606	7 APR	16:45	VIBRATORY	-36.1	3.9	>4.0	2.9	1.0	
SA-15	1,461,132	522,555	9 APR	09:51	VIBRATORY	-36.8	3.2	>3.2	2.2	1.0	
SA-16	1,461,295	522,592	7 APR	17:51	VIBRATORY	-37.5	2.5	>10.0	1.5	1.0	
SA-17	1,461,251	522,541	7 APR	17:20	VIBRATORY	-37.5	2.5	>4.0	1.5	1.0	
SA-18	1,461,208	522,490	9 APR	10:12	VIBRATORY	-35.0	5.0	>5.0	4.0	1.0	
SB-19	1,461,370	522,528	8 APR	09:12	VIBRATORY	-38.1	1.9	>4.0	0.9	1.0	2 gravity corer attempts 4/6
SB-20	1,461,327	522,477	8 APR	09:27	VIBRATORY	-37.1	2.9	>4.0	1.9	1.0	2nd attempt
SB-21	1,461,284	522,426	9 APR	10:28	VIBRATORY	-36.0	4.0	>4.0	3.0	1.0	
SB-22	1,461,447	522,463	8 APR	10:00	VIBRATORY	-33.9	6.1	>8.0	5.1	1.0	
SB-23	1,461,404	522,412	8 APR	09:43	VIBRATORY	-37.5	2.5	>3.0	1.5	1.0	
SB-24	1,461,360	522,361	9 APR	10:42	VIBRATORY	-36.4	3.6	>3.6	2.6	1.0	
SB-25	1,461,523	522,398	8 APR	10:30	VIBRATORY	-36.7	3.3	>3.3	2.3	1.0	
SB-26	1,461,480	522,347	8 APR	10:16	VIBRATORY	-37.0	3.0	>3.0	2.0	1.0	
SB-27	1,461,436	522,296	9 APR	10:57	VIBRATORY	-35.9	4.1	>4.1	3.1	1.0	
SB-28	1,461,616	522,348	8 APR	10:54	VIBRATORY	-39.1	0.9	>5.0	---	1.0	Kept 1 ft for lower only
SB-29	1,461,556	522,282	8 APR	10:45	VIBRATORY	-37.6	2.4	>5.0	1.4	1.0	
SB-30	1,461,513	522,231	9 APR	11:58	VIBRATORY	-36.6	3.4	>4.0	2.4	1.0	
SB-31	1,461,693	522,284	8 APR	-----	-----	>-40	---	----	---	---	Below project depth

TABLE 1. (continued)

Station	California State Zone III Coordinates East (X)	California State Zone III Coordinates North (Y)	Date Sampled	Start Time	Corer Type	Corrected Depth (MLLW)	Required Core (ft)	Collected Core (ft)	Length Upper (ft)	Length Lower (ft)	Comments
Short Cores: Santa Fe Channel (continued)											
SB-32	1,461,649	522,231	8 APR	-----	-----	>-40	---	----	---	---	Below project depth
SB-33	1,461,589	522,167	9 APR	11:44	VIBRATORY	-36.4	3.6	>4.0	2.6	1.0	
SB-34	1,461,770	522,220	8 APR	-----	-----	>-40	---	----	---	---	Below project depth
SB-35	1,461,701	522,134	8 APR	12:55	VIBRATORY	-36.9	3.1	>3.1	2.1	1.0	
SB-36	1,461,665	522,102	8 APR	14:40	VIBRATORY	-37.1	2.9	>2.9	1.9	1.0	
SC-37	1,461,847	522,156	8 APR	-----	-----	>-40	---	----	---	---	Below project depth
SC-38	1,461,785	522,088	8 APR	13:15	VIBRATORY	-38.2	1.8	>1.8	0.8	1.0	
SC-39	1,461,741	522,037	8 APR	14:47	VIBRATORY	-38.1	1.9	>1.9	0.9	1.0	
SC-40	1,461,924	522,092	8 APR	-----	-----	>-40	---	----	---	---	Below project depth
SC-41	1,461,861	522,024	8 APR	13:34	VIBRATORY	-38.3	1.7	>1.7	0.7	1.0	
SC-42	1,461,818	521,973	8 APR	15:09	VIBRATORY	-36.9	3.1	>4.0	2.1	1.0	
SC-43	1,462,001	522,028	8 APR	-----	-----	>-40	---	----	---	---	Below project depth
SC-44	1,461,937	521,959	8 APR	14:02	VIBRATORY	-38.8	1.2	>4.0	0.2	1.0	
SC-45	1,461,894	521,908	8 APR	15:25	VIBRATORY	-37.4	2.6	>4.0	1.6	1.0	
SC-46	1,462,078	521,964	8 APR	-----	-----	>-40	---	----	---	---	Below project depth
SC-47	1,462,013	521,894	8 APR	15:55	VIBRATORY	-38.4	1.6	>4.0	0.6	1.0	
SC-48	1,461,970	521,843	8 APR	15:40	VIBRATORY	-36.3	3.7	>4.0	2.7	1.0	
SC-49	1,462,154	521,900	8 APR	-----	-----	>-40	---	----	---	---	Below project depth
SC-50	1,462,900	521,829	8 APR	16:25	VIBRATORY	-38.5	1.5	>4.0	0.5	1.0	
SC-51	1,462,046	521,778	6 APR	16:16	VIBRATORY	-36.3	3.7	>3.7	2.7	1.0	
SC-52	1,462,231	521,836	8 APR	-----	-----	>-40	---	----	---	---	Below project depth
SC-53	1,462,187	521,783	8 APR	-----	-----	>-40	---	----	---	---	Below project depth
SC-54	1,462,123	521,714	8 APR	16:42	VIBRATORY	-36.3	3.7	>4.0	2.7	1.0	
SC-55	1,462,308	521,772	8 APR	-----	-----	>-40	---	----	---	---	Below project depth

TABLE 1. (continued)

Station	California State Zone III Coordinates		Date Sampled	Start Time	Corer Type	Corrected Depth (MLLW)	Required Core (ft)	Collected Core (ft)	Length Upper (ft)	Length Lower (ft)	Comments
	East (X)	North (Y)									
Short Cores: Santa Fe Channel (continued)											
SC-56	1,462,242	521,700	8 APR	15:17	VIBRATORY	-37.9	2.1	>4.0	1.1	1.0	
SC-57	1,462,199	521,649	8 APR	17:08	VIBRATORY	-35.8	4.2	>4.2	3.2	1.0	
SC-58	1,462,385	521,708	6 APR	-----	-----	>-40	---	----	---	---	Below project depth
SC-59	1,462,318	521,635	8 APR	17:48	VIBRATORY	-37.2	2.8	>2.8	1.8	1.0	2 gravity corer attempts 4/6
SC-60	1,462,275	521,584	8 APR	17:34	VIBRATORY	-35.7	4.3	>4.3	3.3	1.0	2 gravity corer attempts 4/6
Long Cores: Richmond Harbor Channel											
RI-1-W-1	1,462,151	521,548	9 APR	16:46	VIBRATORY	-17.0	23.0	¯2	----	----	Corer penetrated to 25 ft, but was plugged with clay and gravel. Sediment was not kept.
RI-1-W-1A	1,462,204	521,557	9 APR	17:55	VIBRATORY	-26.2	13.8	¯1.5	----	----	Corer penetrated 13 ft, again plugged with clay, gravel. All material saved as sample.
RI-1-TC-1	1,463,673	516,865	10 APR	18:10	VIBRATORY	-10.7	29.3	25**	----	----	Too short, not kept.
RI-1-TC-1	1,463,673	516,865	11 APR	08:26	VIBRATORY	-5.2	34.8	23**	N/A(a)	N/A	Corer penetrated 39 ft of mud. Recovered core kept (6 sections)
RI-1-TC-2	1,463,772	517,295	11 APR	09:16	VIBRATORY	-5.2	34.8	25**	N/A	N/A	Corer penetrated 41 ft of mud. Recovered core kept (5 sections)
RI-1-TC-3A	1,463,731	517,608	11 APR	10:15	VIBRATORY	-6.9	33.1	22**	N/A	N/A	Corer penetrated 40 ft of mud. Recovered core kept (5 sections)

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* and ** -- See text for explanation of results.

TABLE 1. (continued)

Station	California State Zone III Coordinates East (X)	North (Y)	Date Sampled	Start Time	Corer Type	Corrected Depth (MLLW)	Required Core (ft)	Collected Core (ft)	Length Upper (ft)	Length Lower (ft)	Comments
Long Cores: Richmond Harbor Channel (continued)											
RI-1-TC-4	1,463,680	517,851	11 APR	10:53	VIBRATORY	-6.2	33.8	24**	N/A	N/A	Corer penetrated 38 ft of mud. Recovered core kept (6 sections)
RI-1-TC-5	1,463,561	518,187	11 APR	13:05	VIBRATORY	-20.1	19.9	17.0**	N/A	N/A	Corer penetrated 25 ft of mud. Recovered core kept (4 sections)
Water sample: Santa Fe Channel											
SB-35	1,461,701	522,134	8 APR	12:20	THREE WATER SAMPLES COLLECTED - SFC #1, #2, #3						

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* and ** -- See text for explanation of results.

(a) Cores were not divided into upper and lower sections in the field. Sections for chemical analysis will be determined in laboratory.

sufficient sediment for analysis and/or archiving, the station was relocated as closely as possible to the original location. The surveyor in the small boat would circle the station while watching the fathometer until an appropriate depth was found. The buoy would then be reset and the revised coordinates and new depth recorded. In Richmond Harbor Channel, revised locations were generally closer to the edge of the channel. In Santa Fe Channel, if a station could not be relocated within a 25-ft radius of the original station, the entire grid square was assumed to be too deep and therefore was not sampled.

2.3 SAMPLING EQUIPMENT AND PROCEDURES

2.3.1 Sediment Samples

Introduction

Sediment core samples from Richmond Harbor and Santa Fe Channels were collected with one of two types of coring devices. Because most core lengths were not expected to exceed 10 feet (short cores), it was planned that sampling at most sites would be attempted with a gravity corer. At sites in previously undredged areas (long cores) and where the gravity corer was unsuccessful, a vibratory-hammer corer was to be used. Both the gravity corer and the vibratory corer accommodate a 3.625-in. ID core liner of polycarbonate Lexan. All core liners were steam-cleaned prior to use. The procedures for collecting cores with these two types of corers are detailed in the following sections.

Gravity Coring

The gravity coring device was designed to drop through the water column and penetrate sediments under its own weight and momentum. The device consisted of a 10-ft core barrel with a 4-in. inner diameter capable of collecting an 8-ft core (Figure 5). The lower end of the barrel was threaded to accommodate a cutter head designed to collect a relatively undisturbed sample. Three fins were welded to the top end of the core barrel to prevent deflection as it dropped. A bolt through the core barrel held the top of the core liner in place, and a bail welded over the top of the barrel connected it to the haul cable.

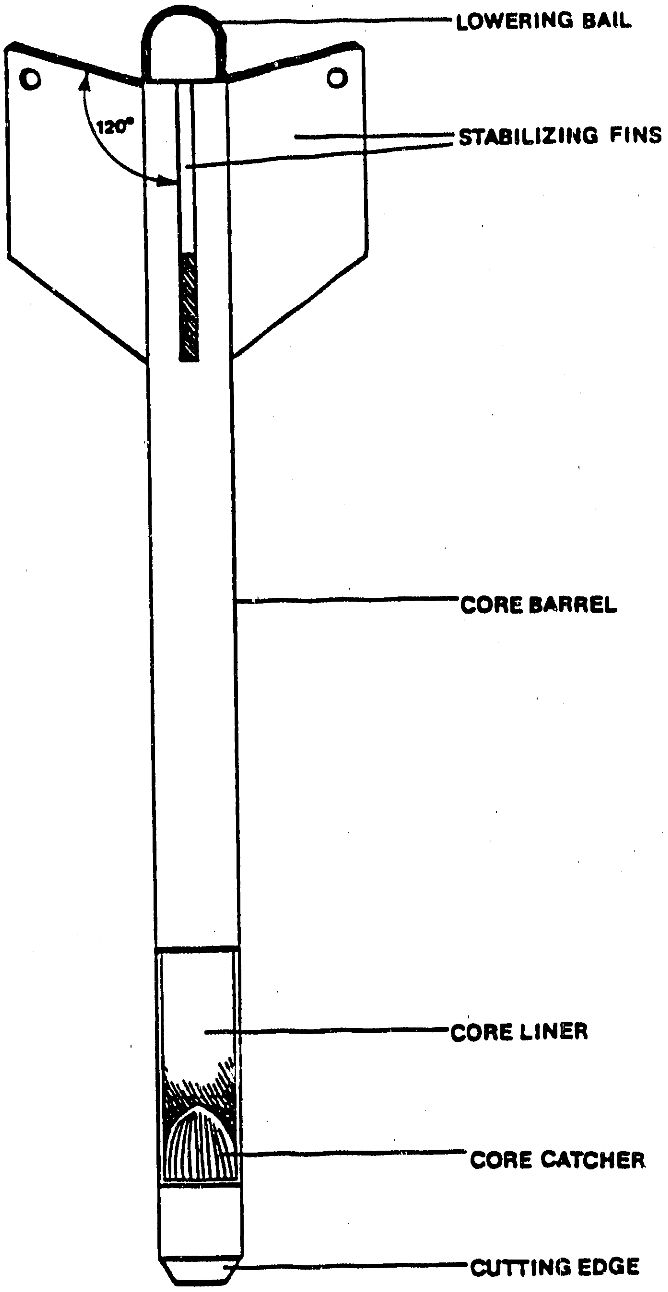

FIGURE 5. GRAVITY CORER USED TO COLLECT RICHMOND HARBOR SEDIMENT.

To collect a gravity core, a 10-ft section of Lexan core liner was loaded into the core barrel. One or more core retainers were inserted into the lower end of the core liner, after which the cutter head was screwed on to secure the core liner in the barrel. The gravity corer was deployed from a 20-ft jib mounted on the stern of the tugboat California Eagle. When the vessel was on-site, the corer was lowered to the water surface and allowed to free-fall through the water column and penetrate the sediment. A winch powered by compressed air was used to retrieve the corer onto the deck. The full core liner was removed from the barrel and measured from the mud line to the bottom of the core. If the attempt was successful (i.e., the full required core depth was collected), the core was capped, labeled, cut into sections, and stored as described later in this section. If the attempt was unsuccessful and the required length was not collected, additional attempts were made. If these also proved unsuccessful, the site was revisited with the vibratory corer.

Vibratory-Hammer Coring

The vibratory coring apparatus, operated by Manson Pacific, consists of a 50-ft long, 4-in. ID core barrel. Depending on the length of core required, the barrel can be loaded with 10-, 20-, 30-, or 40-ft sections of Lexan core liner. The core-retainer and cutter-head assemblage is the same as that used on the gravity corer. The outside of the barrel is marked at 1-ft intervals to measure the depth of penetration as the corer descends. The top end of the vibracore barrel connects to a 6-ton electric vibrating hammer suspended from the 150-ft boom of the crane aboard the derrick barge DB-17.

To collect a vibracore sample, the barge was maneuvered into position by the tugboat Bearcat and then two stern anchors and one bow anchor were set. To save time in anchoring, the barge was usually positioned where several sites could be sampled without re-anchoring. The crane was used to lift the vibratory hammer and core barrel off the barge deck and suspend them over the water. The hammer was then coupled to the barrel and the apparatus slowly lowered through the water at the sampling site. If the weight of the vibratory hammer alone was not sufficient to push the core barrel to sufficient depth, the hammer was switched on to vibrate the corer through the sediment until the necessary depth was achieved. The crane then raised the core barrel out of the water and lowered it onto the deck. The sediment-filled core liner was pulled from the barrel and measured. Additional attempts were made at the site if an insufficient amount of sediment was collected on the first try. If the core sample was long enough, the core was capped, labeled, cut into sections, and stored in a freezer at 4°C on board the sampling vessel.

Core Sample Handling

Once a core was collected, it was measured to see if sufficient sediment was recovered. Successful core samples were then capped, labeled, and cut into sections. Short cores from Richmond Harbor Channel were cut into upper (shallower than -39 ft MLLW) and lower (deeper than -39 ft MLLW) sections. The upper section represents the material to be dredged from the channel, while the lower section represents material that would be exposed as a result of dredging. Cores of the material to be exposed (deeper than -39 ft MLLW) from each reach (A, B, and C) of Santa Fe Channel were cut to 1 ft in length (-39 to -40 ft MLLW). The lower sections of all short cores and the upper sections of 16 of the short cores from Richmond Harbor Channel were to be archived intact for possible future analyses. These sections were flagged with fluorescent tape and labeled for ease in sample tracking. Any sections that exceeded 5 ft in length were cut into two shorter pieces to facilitate handling and storage. Long cores from the proposed widening and turning areas (Station RI-1-W and RI-1-TC stations) were also cut into 5-ft sections. The sealed core sections were stored in a freezer at 4°C aboard the sampling vessel until the end of the day, when they were transferred to a refrigerated truck. Sediment sample chain-of-custody records were kept up to date daily as cores were loaded onto the truck.

2.3.2 Water Sampling

A vacuum pump was used to collect water samples from Santa Fe Channel. Water from 18 in. below the surface was pumped through acid-cleaned, solvent-rinsed Teflon tubing into clean, labeled 5-gal glass carboys. Each carboy was sealed with a clean neoprene stopper lined with a clean sheet Teflon, then stored at 4°C aboard the sampling vessel. At the end of the day, the water samples were transferred to a refrigerated truck, where they were held at 4°C until delivery to the MSL. A water sample chain-of-custody record was initiated when samples were loaded onto the truck.

2.4 FIELD SAMPLING RESULTS

2.4.1 Short Cores: Richmond Harbor Channel and Santa Fe Channel

The initial field sampling strategy called for attempting all the short-core stations (Stations RI-1-C-1 through RI-1-C-42 and Stations SA-1 through SC-60) (Figures 2, 3, and 4) with the small tug and gravity corer, then returning to any unsuccessful sites with the barge and vibracorer. After spending April 5 and 6 gravity coring aboard the California Eagle, it was evident that the barge and vibracorer combination would be more effective and efficient. In those two days, over 40 sampling attempts were made at 31 stations in both Richmond Harbor and Santa Fe Channels. When a particularly stiff layer of sediment was encountered, the weight of the gravity corer was not sufficient to penetrate the sediment to the required depth. If a successful sample (i.e., sufficiently long) could not be collected after 2 or 3 attempts, the site was revisited with the barge and vibracorer. At nine stations in Richmond Harbor Channel and one station in Santa Fe Channel (single asterisks in Table 1), the core collected was shorter than -40 ft MLLW but longer than -39 ft MLLW. These cores were not resampled, because the USACE representative on board pointed out that the bottom sections were going to be archived, so it would not be worthwhile to resample for the few missing inches of core. During archiving of the short Santa Fe core, all the available lower section was composited. Thirteen Richmond Harbor Channel stations were successfully sampled with the gravity corer (Table 1). The remaining 29 short cores in Richmond Harbor Channel and all of the cores in Santa Fe Channel were collected by vibratory coring as described in the previous section.

Vibratory coring commenced on April 7 in Santa Fe Channel. Successful short cores were obtained from 12 sites on the first day and 25 sites on the second day. Of the 60 stations in Santa Fe Channel, 12 were already below project depth (below -40 ft MLLW): SB-31, SB-32, SC-37, SB-34, SC-40, SC-43, SC-46, SC-49, SC-52, SC-53, SC-55, and SC-58 (Figure 4). One site, SB-28, was so deep that only the lower section (between -39 and -40 ft MLLW) could be sampled. Most of these sites are on the northwest edge of the channel between the mouth of Lauritzen Canal and the junction with Richmond Harbor Channel. The remaining Santa Fe Channel sites were sampled early on the third day (April 9), then the barge moved into Richmond Inner Harbor Channel and successfully cored at eight stations. Short cores from all 21 remaining Richmond Harbor Channel stations were collected with the vibratory corer on April 10.

2.4.2 Long Cores (Undredged Areas)

The USACE plan for improvements in Richmond Harbor calls for widening the entrance to Santa Fe Channel and for establishing a large turning basin east of Point Potrero. To characterize the sediments from these previously undredged areas, it was necessary to collect undisturbed cores that were 20 to 35 ft in length. One core from Station RI-1-W-1 was intended to represent the material to be removed from widening the entrance to Santa Fe Channel. This site was visited on April 9. The first attempt (Station RI-1-W-1) resulted in sufficient penetration of sediment (25 ft), but the sediment was not retained in the core liner. The site was relocated to slightly deeper water (Station RI-1-W-1A) and a second attempt made. On this attempt, the cutter head and bottom of the core liner were plugged with approximately 2 ft of gravel and pebbles embedded in very stiff clay. Even though the core barrel had penetrated the sediment to -40 ft MLLW, the gravel and clay encountered near the surface prevented any more material from entering the barrel as it pushed down through the sediment. The material collected from Station RI-1-W-1A, though it was not an undisturbed core, was capped and sealed in a short section of Lexan (approximately 2 ft long) and saved for analysis.

Five sampling sites were located in the proposed turning basin east of Point Potrero (Figures 2 and 3). Corrected mudline depths at these stations (RI-1-TC-1 through RI-1-TC-5) ranged from -5.2 to -20.1 ft MLLW, requiring cores 20 to 35 ft in length. Vibracoring at these stations was completed on April 11, although one unsuccessful attempt at Station RI-1-TC-1 was made on April 10. The water at Station RI-1-TC-3 was too shallow at high tide for the boat to be positioned. Hence, the station was relocated 163 ft west of the planned site and was then called Station RI-1-TC-3A. At all five stations, markings on the core barrel indicated penetration of sediment to -40 ft MLLW. However, in all cases, the amount of sediment retrieved in the core was less than the required core length (double asterisks in Table 1). Geologists often credit this loss to compaction of the sediment as the core barrel pushes through deeper sediment. Alternatively, compacted sediments in the core may have prevented some material from entering the core if the new material was less compact than the material already in the core. Apparent core loss is discussed in more detail in Section 3.6.2.

To minimize vibration as the long cores were taken, the core barrel was allowed to drop through the sediment as far as possible before the vibratory hammer was turned on. Because the entire length of the long cores was to be examined by a geologist in the laboratory, the cores were cut into 5-ft pieces rather than divided into upper and lower sections. The results of the geological analysis of the turning-basin cores are presented in Section 3.6.

2.4.3 Water Samples

On April 8, approximately 10 gal of subsurface water was collected near the center of Santa Fe Channel, 40 ft northeast of station SB-35. Three carboys were each filled about two-thirds full to obtain a total of at least 10 gal.

3.0 LABORATORY PREPARATION

3.1 INTRODUCTION AND OBJECTIVES

The laboratory preparation step encompassed all activities between delivery of field samples to MSL and chemical analysis of samples. These activities included geological analysis of long cores, compositing of bulk sediment samples, preparation of interstitial water and elutriate samples, and sample tracking. Specific objectives of laboratory preparation were:

1. To avoid sample contamination or alteration of physical and chemical properties by using proper sample storage and preservation techniques and uncontaminated glassware and laboratory equipment.
2. To provide detailed chain-of-custody information on the storage and handling of all sediment core and bulk water samples.
3. To process core samples from Santa Fe and Richmond Harbor Channels (both long and short cores) by longitudinally splitting in half cores of interest for bulk sediment chemistry and half-core archiving and by archiving whole selected cores.
4. To provide geological descriptions of long cores from Richmond Harbor Channel to assist USACE in deciding which depth fractions to analyze chemically.
5. To sample for chemical analysis one half of the upper portion of the Richmond Harbor Channel short cores that had been halved longitudinally and to archive both the half-core not used for sampling and the whole core containing the sediment below -39 feet MLLW.
6. To process Santa Fe Channel short cores into six composite samples: the upper sections of cores from Reaches A, B, and C (Figure 4) and the lower sections from Reaches A, B, and C.
7. To isolate interstitial water for chemical analysis from selected Santa Fe Channel sediment composites.
8. To prepare elutriate water for chemical analysis from the three sediment composites of the upper core sections from Santa Fe Channel.

All laboratory preparation activities took place between April 14 and April 28, 1989, the two weeks immediately following the arrival of samples at the MSL. To meet critical holding-time deadlines for chemical analysis, sediment and water samples were processed as efficiently as possible. The following sections present in detail the steps involved in laboratory preparation.

3.2 LABORATORY GLASSWARE AND EQUIPMENT PREPARATION

All laboratory glassware and equipment was cleaned prior to use to prevent contamination. Stainless-steel utensils used for core cutting, sediment mixing, and short-term sediment storage were washed with warm, soapy water, rinsed five times with deionized water, and allowed to air dry. Immediately before use, the utensils were rinsed twice under a fume hood with methylene chloride, which was allowed to evaporate. Glass jars with Teflon-lined caps were used to contain sediment samples for organics analysis. Glass containers were washed in warm soapy water, rinsed five times with deionized water and allowed to air dry, then rinsed twice with methylene chloride and allowed to dry under a fume hood. Teflon and plastic jars were used to hold sediment and water destined for metals analysis. Teflon and plastic containers were washed in soapy water, rinsed five times with deionized water, then placed in a 5% nitric acid bath for a minimum of 4 h. After removal from the acid, the containers were rinsed five times with deionized water, then allowed to air dry.

3.3 SAMPLE STORAGE AND CHAIN-OF-CUSTODY

All sediment and water samples received at MSL were immediately stored in a dark walk-in cold room at 4°C. Sediment cores were stored in a vertical position in core racks and moved only when sampled or archived. Water samples were stored in the original carboys in strong fiberboard protective boxes. Chain-of-custody was maintained from the initial collection through sample analysis and archiving using the forms contained in Appendix A.

3.4 SEDIMENT SAMPLE PREPARATION

3.4.1 Core Cutting and Archiving

Sediment cores from Santa Fe and Richmond Harbor Channels were either archived whole or split longitudinally, with one-half used for bulk sediment analysis and the other half archived. Core sections that were archived whole included all lower sections (where collected) of Richmond Harbor short cores as well as the upper sections of selected Richmond Harbor short cores (Figure 3). Cores to be archived whole were placed horizontally in a large chest freezer with original seals and field labels intact. Core labels were logged onto a freezer inventory form as cores were archived.

Sediment samples for chemical analysis were prepared from the upper sections of Richmond Harbor and Santa Fe Channel short cores, from the lower sections of Santa Fe Channel short cores, and from selected sections along the entire length of Richmond Harbor long cores. These cores were removed carefully from the cold room to avoid disturbing the overlying water. The core was taken to the cutting area, one cap removed, and the overlying water carefully poured off. The core was then placed in a horizontal position on the cutting platform and cut into two equal longitudinal parts by first scoring the liner on opposite sides with a circular saw, then cutting completely through the liner with a stainless-steel linoleum knife. A large stainless-steel knife was then run down the sediment, splitting it into two halves. The half of the core containing the original core label was used for geological analysis (if required) and for sediment chemistry. The other half was wrapped in sheet Teflon, sealed with duct tape, and affixed with a duplicate label. The wrapped half-core was then placed in a large chest freezer and its label recorded on a freezer inventory form (Appendix A). Tests run by NOAA on the time that samples can be held frozen without change in chemistry indicate that PCBs, pesticides, PAHs, metals, and organotins can all be held up to 3 years (Eric Crecelius, personal communication). Traditionally, frozen cores for USACE projects are held for 1 year; the Richmond Harbor cores will be kept until the report is finalized.

3.4.2 Mixing of Sediment Samples

After cores were split longitudinally, sediment was removed from the core liner with a stainless-steel spatula into a labeled 13-L stainless-steel bowl. Care was taken to avoid sampling sediment in direct contact with the core liner or sediment containing pieces of the liner resulting from the cutting process. Sediment was mixed with the stainless-steel spatula until the color and texture indicated a homogenous mixture. A sample preparation form (Appendix A) was completed as each core was sampled and the sediment mixed.

Information recorded on the form included the station number, vertical section(s) of core sampled, a number code relating the sample to a station, and a letter code indicating the group of compounds to be analyzed. In the case of Santa Fe Channel, a number of cores were combined to form a composite sample (Section 3.4.5), and each core was identified on the sample preparation form.

Immediately after mixing, aliquots of the sediment were removed to prelabeled jars for chemical analysis. These aliquots included samples for metals, total organic carbon (TOC), organotins, oil and grease, organic compounds, and physical characteristics. Bulk sediment samples were delivered immediately to the testing labs with an accompanying sample custody form (Appendix A). A total of 55 sediment samples were mixed: 22 from the widening area and turning basin, 27 from existing Richmond Harbor Channel, and six from Santa Fe Channel.

3.4.3 Richmond Harbor Long Cores

To augment the characterization of sediment from the previously undredged areas, a geological description and classification of the long cores was performed by an MSL geologist. The results of this analysis assisted USACE in determining the length and number of vertical sections to be sampled for chemical analysis. Included in the geological analysis were physical measurements of core length and comments on lithology, dilatancy, toughness, plasticity, type, color, consistency, cementation, structure, HCl reaction, maximum particle size, odor, and additional information. The method used for this description was the American Society for Testing and Materials (ASTM) Procedure D2488-84, "Description and Identification of Soils (Visual-Manual Procedure)," described in Appendix B. Also included in Appendix B are the detailed results of the geological description; a discussion of Richmond Harbor geology is presented in Section 3.6.

In the laboratory, the sections of the long cores were examined by USACE representatives and MSL scientists to decide how these sections were to be divided into samples for chemical analyses. The sections were determined based on layering of the sediments. Four samples (new sections) were taken per long core, except for Station RI-1-TC-5, which was divided into five samples. Once the length and number of vertical sections of each long core had been determined by the geologist and USACE, the sediment from each vertical section was mixed into a bulk sediment sample for chemical analysis, as described in Section 3.4.2.

3.4.4 Richmond Harbor Channel Short Cores

A total of 27 sediment samples were prepared from Richmond Harbor Channel short cores. The upper core sections from 26 stations were cut, sampled, and mixed as described in Sections 3.4.1 and 3.4.2. In addition, the lower section from Station RI-1-C-14 was sampled, mixed, and analyzed at the request of USACE to bracket sediment from the middle section that was lost during field sampling. All remaining lower sections of Richmond Harbor Channel short cores were archived whole as described in Section 3.4.1.

Geological descriptions were not performed on the short cores because the vertical section to be analyzed (upper) was predetermined; however, the section length and any remarks about the sediment were recorded on the sample preparation form (Appendix A). Sediment was removed from each core, composited, and split into aliquots for chemical analysis, as described in Section 3.4.2.

3.4.5 Santa Fe Channel Composite Preparation

Although a total of 48 cores were collected from Santa Fe Channel, only six bulk sediment samples were prepared from them. The scheme for compositing cores from Santa Fe Channel was designed by USACE's Waterways Experiment Station. The channel was divided into three reaches: Reach A, Reach B, and Reach C (Figure 4). The upper sections of all cores within a reach were combined into one sediment sample, as were the lower sections of all cores within a reach. Because the cores had already been divided into upper and lower sections in the field, each section could be cut longitudinally, as described in Section 3.4.1.

A sediment composite was created from 14 to 18 core sections. On a sample preparation form (Appendix A), the station, core length, sediment consistency, and volume of sediment contributed to the composite were recorded. As each core was cut, the sediment was carefully removed to a 30-qt stainless-steel bowl, which was kept covered with sheet Teflon until all cores for one composite were cut. The sediment was mixed as each core was added. When the composite was consistent in color and texture, aliquots for chemistry were immediately placed into prelabeled jars. The stainless-steel bowl was covered with sheet Teflon and temporarily stored in the cold room until preparation of interstitial water and elutriate samples. Interstitial water and elutriate preparation began within 12 h and 2 h respectively.

3.5 WATER SAMPLE PREPARATION

3.5.1 Interstitial Water Preparation

Interstitial water was prepared from the three composites of upper material from Santa Fe Channel. It was hoped that water content of the sediment would be high enough to yield interstitial water from the composite of lower sections (material exposed as a result of dredging) as well, but this was not the case. Interstitial water was isolated from the sediment composites from upper cores by filling clean 0.5-L Teflon jars with sediment from the 30-qt mixing bowl. These jars were capped and centrifuged for 45 min at maximum speed in a modified clothing extractor. After centrifugation, the supernatant water in the jars was poured into a clean 1-gal jar, purged with nitrogen gas to prevent oxidation, and the jar quickly capped and placed in the cold room at 4°C. The Teflon jars were refilled with sediment from the stainless-steel bowl and centrifuged; the supernatant was added to the 1-gal jar. This process was repeated until approximately 3 L of interstitial water were collected.

When the appropriate volume of interstitial water was collected, the jar was gently shaken to homogenize the water, and the water was poured into centrifuge tubes and centrifuged for 1 h at 1200 x g on a CRU-5000 centrifuge to remove particles >0.45 μm diameter. After centrifugation, the sample water was transferred into sample containers containing unique labels noted on the sample preparation form (Appendix A). Samples for metals analysis were immediately preserved with 1 μL concentrated hydrochloric acid (HCl) per milliliter of sample. Samples for organics analysis were shipped within one day of preparation. Samples for metals and organotins were transferred to the analytical laboratory when preparation of all samples was complete. Chain-of-custody forms (Appendix A) accompanied each shipment or transfer of samples to the analytical laboratories.

3.5.2 Elutriate Water Preparation

Elutriate water samples were prepared from composites of Santa Fe Channel Reach A, B, and C upper material. The procedure followed was that described by Palermo (1986). The first step in elutriate preparation was calculation of a wet/dry ratio for each sediment sample to be elutriated. Approximately 10 to 20 g (wet) sediment was weighed into each of five preweighed boats, then dried at 105° for 2 h. After drying, the sediment was reweighed and a wet/dry weight ratio was calculated for each of the five samples. The mean wet/dry ratio was used to measure out the sediment needed to obtain 8 L of 150 g/L (dry weight) slurry. The sediment was split equally in half and each half added to a clean 4-L beaker. The beakers were filled with water collected from Santa Fe Channel and the resulting slurry was mixed to uniform consistency with a stainless-steel spoon.

Filtered compressed air was bubbled through the slurry for 1 h, during which time the slurry was periodically mixed with the spoon. Next, the mixing and aeration were stopped and the jars were covered with a watch glass and allowed to settle for 24 h in a refrigerator at 4°C. After settling, the supernatant water was removed from each jar with a Teflon tube siphon and placed in clean glass 1-gal jars. This water was then transferred to centrifuge tubes and centrifuged at 10,000 x g for of 30 min to remove particles >0.45 μm diameter. Water was not filtered because studies conducted at WES indicated that some types of dissolved organic compounds are removed from water by filtering (R. Lee, personal communication). After centrifugation, the water from the centrifuge tubes was transferred directly to sample containers with unique labels which were noted on the sample preparation form (Appendix A). Samples for metals analysis were immediately acidified with 1 μL concentrated HCl per milliliter of sample. Samples for organics analysis were shipped within one day of preparation. Samples for metals and organotins analysis were transferred to the analytical laboratories when preparation of all samples was complete. Chain-of-custody forms

(Appendix A) accompanied each batch of samples as they were transferred.

3.6 GEOLOGICAL ANALYSIS OF LONG CORES

Prior to sampling of core segments from Stations RI-1-TC-1 through RI-1-TC-5 and RI-1-W-1 at MSL, the segments were described geologically. Descriptions were performed according to ASTM Procedure D2488-84, "Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)." Sediment characteristics that were logged included the following:

dry strength of silt/clay
dilatancy of silt/clay
toughness of silt/clay
plasticity of silt/clay
sediment type (i.e., engineering classification)
color
consistency (i.e., firmness)
cementation
sedimentary structure
reaction with hydrochloric acid
maximum particle size
odor

In addition, any other diagnostic features, such as the presence of root traces, mollusc shells, or human-related detritus, were noted. A more detailed description of the materials and methods used for describing the sediment cores is given in Appendix A.

3.6.1 Geology

Two geologic units, the Older Bay Mud (OBM) and the Younger Bay Mud (YBM) (USACE 1975a) are present beneath Richmond Harbor (Figure 6). These two units are differentiated principally on the basis of color and consistency (i.e., firmness). USACE (1988) divided the OBM unit into three formations: the San Antonio, Alameda, and Posey formations. Because the characteristics used to differentiate between these formations are unclear, for the purposes of this discussion stratigraphic units are subdivided on the basis of the interpreted sedimentary environment (i.e., terrestrial/fluvial and

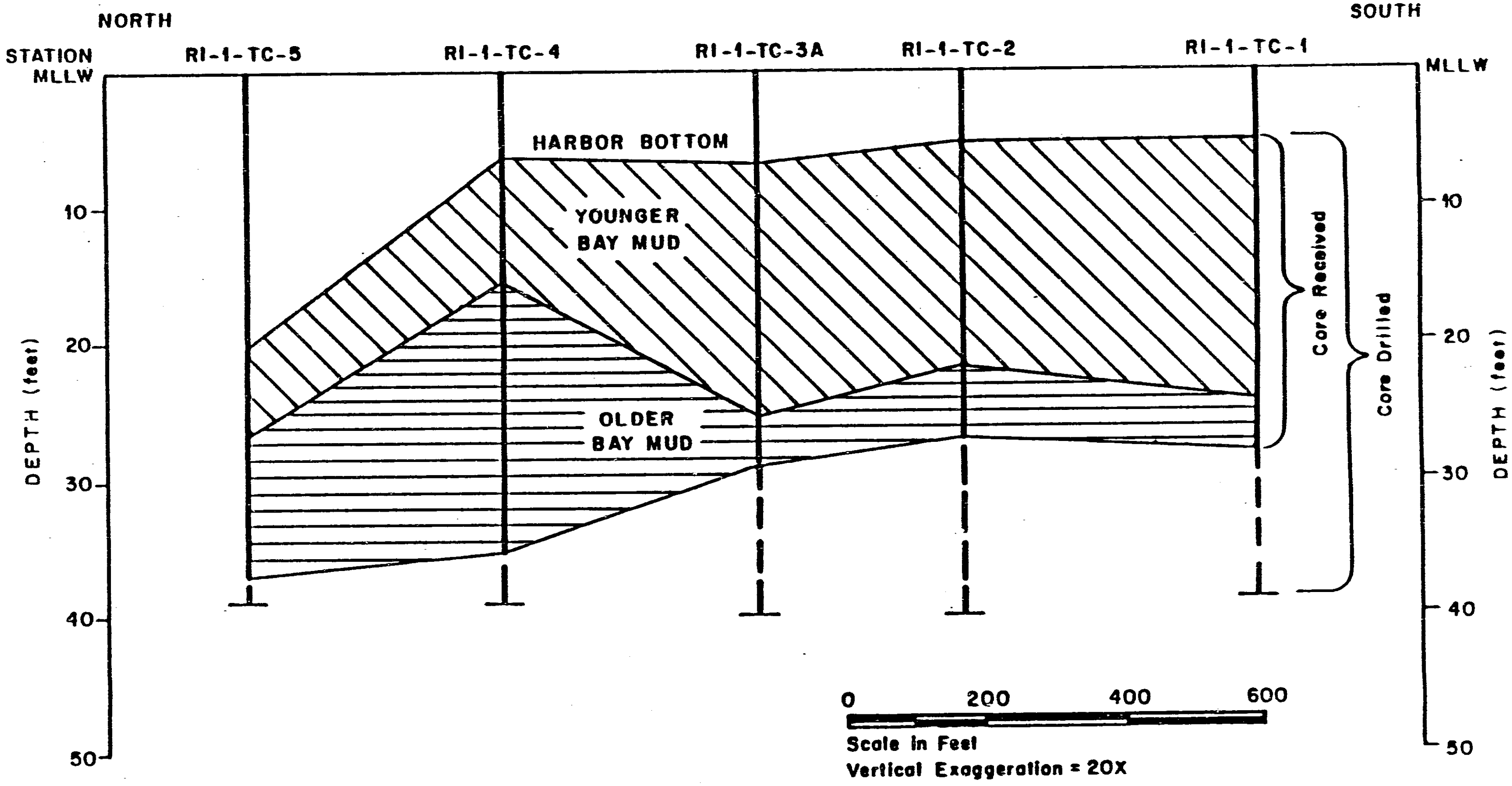

FIGURE 6. GENERAL GEOLOGIC CROSS-SECTION OF PROPOSED TURNING BASIN, NOT CORRECTED FOR CORE LOSS.

marine/estuarine). Terrestrial deposits display features indicative of surface weathering (e.g., root traces that extend and bifurcate downward; bleached and/or oxidized color). Marine deposits are usually dark-colored, due to reducing conditions, and contain mollusc shells. In general, because of the transport mechanisms involved, terrestrial sediments display larger average grain sizes (e.g., sand) than marine deposits, which consist mostly of silt and clay. Deposits locally referred to as "Merritt Sands" appear to be equivalent to coarse-grained terrestrial sediments of the OBM unit.

Three cross-sections are used to show the geology of the proposed Richmond Harbor turning basin (Figures 6, 7, and 8). Figure 6 shows the general nature of the geologic units and the difference between the depth of corer penetration and the amount of recovered sediment in the core. Figure 7 displays more detail, by separating the Older and Young Bay Mud units into three sediment types. Figure 8 shows the same layers as Figure 7, but corrected for apparent core loss. The possible mechanisms of cores loss are discussed in Section 3.6.2.

Older Bay Mud

The OBM unit consists of a wide range of deposits, from loose pebbly sands to stiff, cohesive silts and clays. The OBM unit was deposited during the last interglacial period, when sea level resided as much as 335 ft below its present level (USACE 1975b, 1979). Interglacial periods have occurred at approximately 100,000-year intervals over the last 1 million years or so (Stottlemyre et al. 1981); the most recent interglacial period ended about 125,000 years ago (CLIMAP 1984). Most of the OBM unit was probably deposited about this time; however, some of the unit may have formed during previous interglacial periods. The top of the OBM unit appears to represent an erosional surface, but also may have been modified by past dredging activities; the uneven, eroded nature of the OBM surface is apparent in Figures 7 and 8.

The OBM unit is distinguished by its mostly firm consistency and by its color. Color is particularly useful for the identification of terrestrial sediments, which consist of various shades of red, yellow, and brown. These

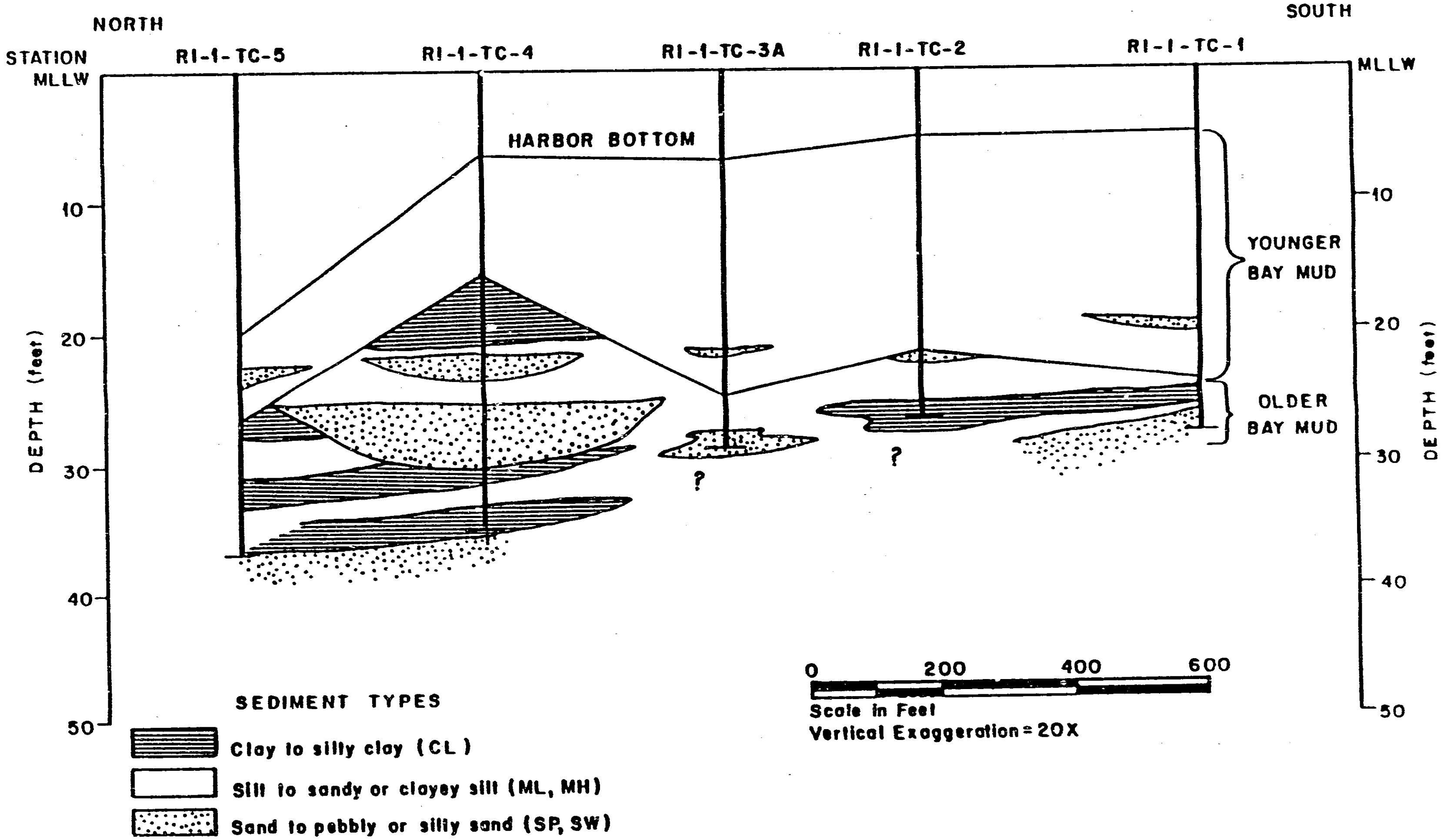

FIGURE 7. DETAILED GEOLOGIC CROSS-SECTION OF PROPOSED TURNING BASIN, NOT CORRECTED FOR CORE LOSS.

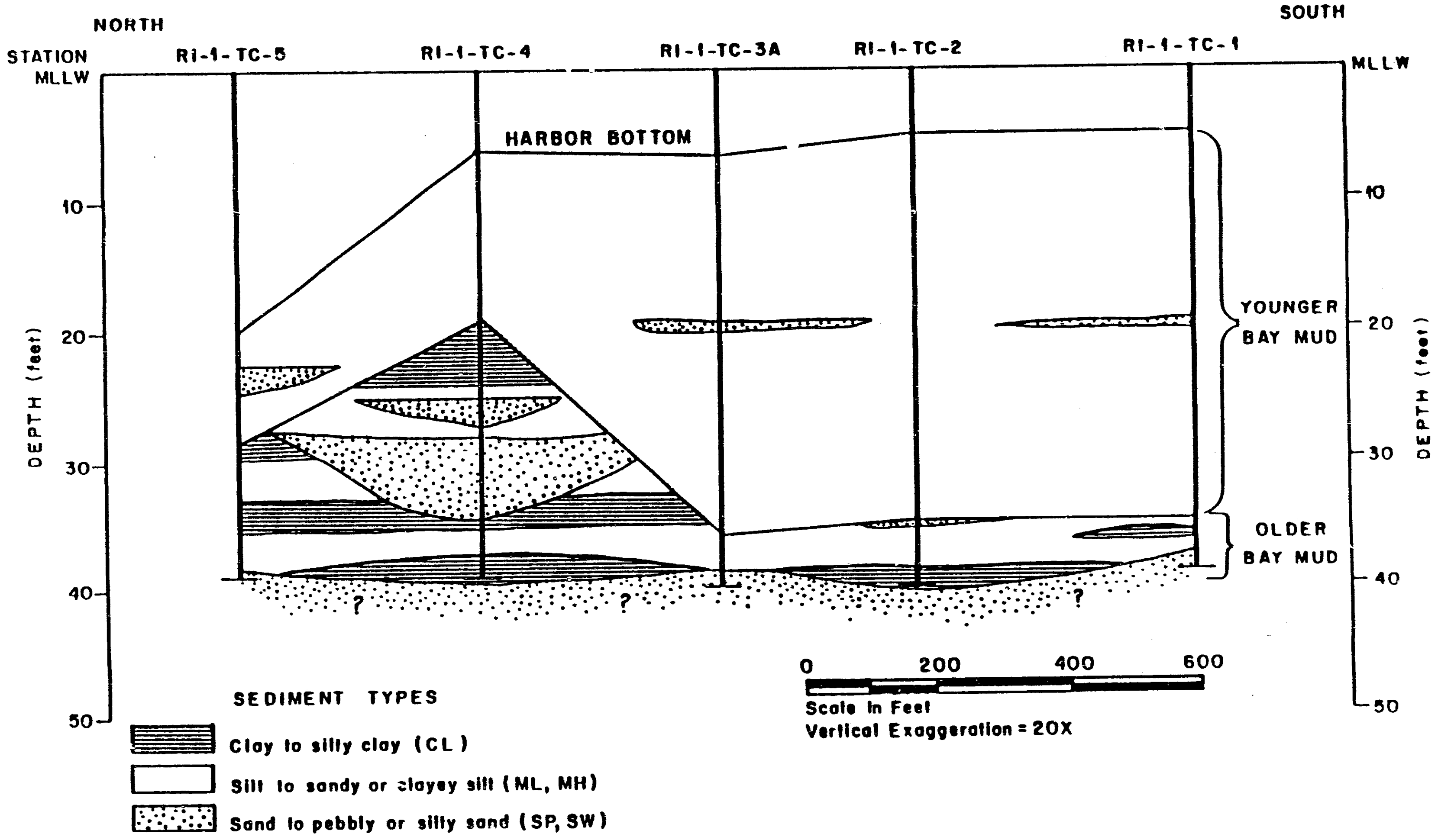

FIGURE 8. DETAILED GEOLOGIC CROSS-SECTION OF PROPOSED TURNING BASIN, CORRECTED FOR CORE LOSS.

colors are consistent with an oxidizing environment associated with deposition by rivers and streams. The presence of deeply penetrating root traces is another indication of terrestrial conditions. The marine portions of the OBM unit, on the other hand, consist of drab-colored shades of olive and gray. These colors, along with the presence of whole mollusc shells, are indicative of a low-energy, reducing, estuary-type environment.

The high degree of compaction and consolidation, in combination with the weathered appearance of the OBM, suggests that this unit is much older than the overlying estuarine sediments belonging to the YBM unit. The highly oxidized, weathered, and compacted nature of the OBM, in combination with the presence of root traces, calcium carbonate, and iron concretions, suggest that the OBM unit underwent alteration during a period of soil development when the area lay above sea level.

Younger Bay Mud

The YBM unit consists mostly of soft, dark-colored sediments deposited in an estuarine environment. These deposits began to be laid down as sea level rose following the last ice age, which ended approximately 12,000 years ago (Barry 1983). The YBM unit appears to form a continuous blanket across the Richmond Harbor bottom. USACE (1975a) subdivided the YBM unit into a Semi-Consolidated Bay Mud member overlain by a Soft Bay Mud member. However, a sudden, characteristic change in consistency, reported by USACE (1979), was not observed within the YBM unit in cores examined in this study. Therefore, it is assumed that the Semi-Consolidated Bay Mud member is not present.

The YBM unit consists mostly of very soft to soft clayey silt. The YBM unit is characteristically dark colored, ranging from gray to dark gray and olive gray. The dark color, in combination with the odor of rotten eggs (i.e., hydrogen sulfide), indicates chemically reduced conditions. The firmness of the YBM unit increases slightly with depth, probably as a result of compaction beneath the weight of the overlying sediments. The YBM unit is not restricted to the present bay area, but also lies above sea level and a considerable distance inland (USACE 1975a). This observation suggests that sea level has been higher at times in the past.

3.6.2 Apparent Core Loss

The cause of large differences in core retrieved versus core drilled is problematic. The percent core loss was calculated as follows:

$$\text{Percent Core Loss} = 100 - \frac{\text{Core Recovered X 100}}{\text{Core Drilled}}$$

All cores, except those from Station RI-1-TC-5, penetrated approximately the same thickness of sediments. As a result, differences in the amount of sediment penetrated can be eliminated as a mechanism to account for the observed differences in core loss. Two other possible mechanisms to account for this phenomenon are the "bullet effect" and compaction. The bullet effect refers to the bulldozing action at the driving end of the core liner when, after a critical depth is reached, soft sediments temporarily cease to move upward within the core liner due to the build up of resistance by the sediments against the inside walls of the liner. Any sediments with a similar consistency will be pushed aside until a more competent layer is intercepted, when sediment should again move upward and be preserved within the core liner. If the bullet effect were occurring, then only the more competent, higher strength sediments would be preserved at depth. However, alternating layers of both soft and compact sediments were preserved from the OBM unit, as indicated in the core logs of Stations RI-1-TC-4 and RI-1-TC-5 discussed below. Furthermore, there were no major discontinuities or breaks in the core to suggest that any sediment layers were bypassed during drilling.

Compaction of sediments, as an alternative mechanism, may occur as a result of the jarring and vibration within the core liner during drilling. Such motion may drive off some of the interstitial water and thus promote settling of the loosely packed sedimentary particles. Regardless of the mechanism, apparent core loss appears to be restricted to the less compacted YBM unit. This is indicated in Figure 9, which shows a strong correlation between the amount of apparent core loss and the thickness of the YBM unit. Accordingly, Stations RI-1-TC-4 and RI-1-TC-5, which had less than 10 ft of YBM, showed only a few feet or less of apparent core loss. On the other hand, significantly greater losses (as much as 12 ft, or 30%) occurred in

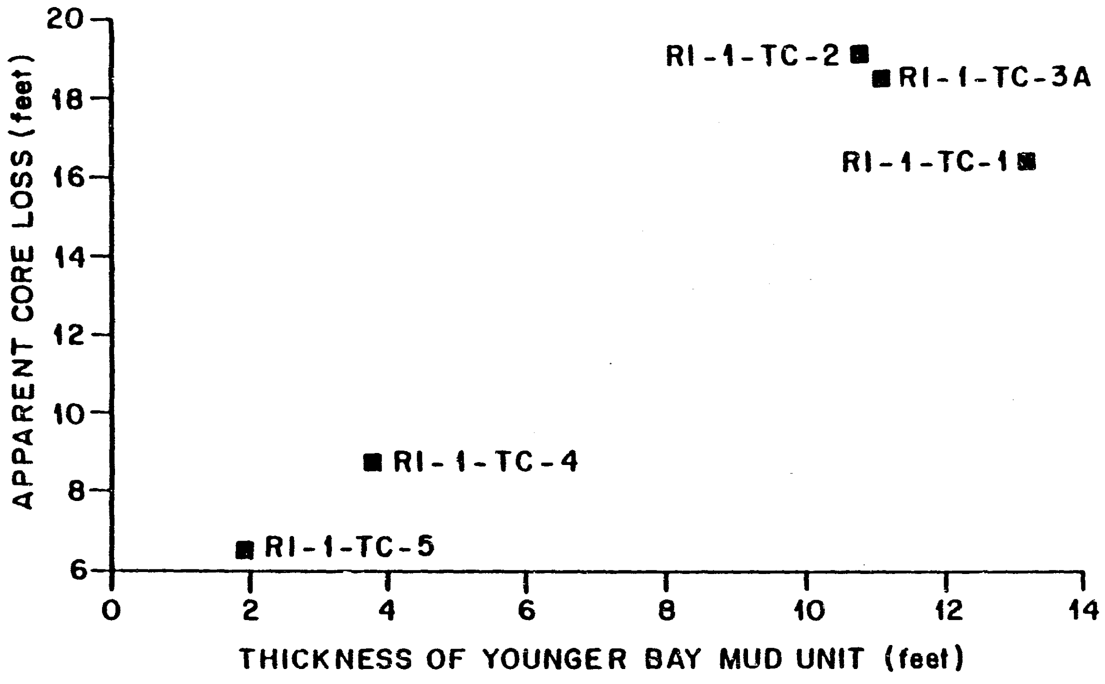

FIGURE 9. RELATIONSHIP OF APPARENT CORE LOSS TO THICKNESS OF YOUNGER BAY MUD UNIT.

Stations RI-1-TC-1, RI-1-TC-2, and RI-1-TC-3, which contained the thickest sequences of YBM. For this reason, the depths to the top of the OBM unit shown in Figure 8 (corrected for apparent core loss) are greater than those in Figures 6 and 7.

A possible way to test the validity of the bullet effect would be to confirm that soft as well as firm sediments are being preserved throughout the length of the core. If indeed soft sediments are being retrieved at depth subsequent to the drilling of more compact sediments, then the bullet effect loses credibility. Sediment consistency at present is determined qualitatively from the deformation of core under thumb pressure. A more quantitative measurement for comparing the consistency of sediment cores (i.e., penetrometer) should be used in the future to estimate core strength and retrievability. Without further field work, the cause of the apparent core loss cannot be determined.

3.6.3 Core Summary Descriptions

Presented below is a general description of each core based on the geologic logs presented in Appendix B.

Station RI-1-W-1

Station RI-1-W-1 was drilled along the northern portion of the Richmond Harbor outside the turning basin. Of the 25 ft of core drilled, less than 2 ft were recovered. The recovered core consists of a well-graded mixture of pebble-cobble gravel, sand, silt, and clay, and probably represents a composite of the entire 25-ft section. This is suggested by the marbled appearance of the differing colors. One of the marbled colors, light olive brown, indicates that some of the recovered core came from the OBM unit.

Station RI-1-TC-1

The soft YBM unit extends to a depth of 19.2 ft below mudline (Figures 6 and 7); however, correcting for apparent core loss, the true depth of the YBM unit lies at a depth of about 30 ft below mudline (Figure 8). Except for a thin sand lens about two-thirds into the YBM unit, the average grain size appears to decrease with depth. Marine mollusc shells were present in the upper half of the YBM unit.

A total of 3.8 ft of OBM was recovered at Station RI-1-TC-1. The OBM unit consists of a gradational sequence ranging from dark-colored fine-grained silt and clay at the top to oxidized, coarse pebbly sand toward the bottom. The consistency of the sequence is firm throughout.

Station RI-1-TC-2

The YBM unit extends to a depth of 16.5 ft below mudline (Figures 6 and 7). Correcting for apparent core loss, however, the true depth of the YBM unit lies at a depth of approximately 29 ft below mudline (Figure 8). The YBM unit is a relatively uniform dark gray clayey silt and contains mollusc shells throughout. A strong sulfide odor came from the lower portion of the YBM unit.

A total of 5.0 ft of OBM was recovered at Station RI-1-TC-2. Only the lower 1.5 ft were firm; the upper portion was soft like the YBM. A thin layer of poorly graded sand lies atop the OBM unit. This overlies an ancient soil deposit containing a high concentration of root fillings and mats of decayed plant matter. Toward the bottom of the OBM sequence are mud concretions formed in a stiff clay matrix, characteristic of soil development, which occurred when the area lay above sea level.

RI-1-TC-3A

The soft YBM unit extends to a depth of 18.5 ft below mudline, while the true depth lies at approximately 29 ft below mudline (Figure 8). Except for two thin sand lenses between the 12 and 15 ft depth, the YBM unit is slightly finer grained below a depth of about 6 ft. The maximum observed depth of mollusc shells is about 11 ft.

A total of 3.5 ft of OBM was recovered at Station RI-1-TC-3A. Olive-gray fine sandy silt grades downward into well-graded grayish brown sand. Carbonate concretions and root fillings, associated with soil development, occur in the upper 1.5 ft of the OBM sequence. The entire OBM sequence shows a firm consistency.

Station RI-1-TC-4

The YBM unit extends to a depth of 8.8 ft below mudline; however, correcting for apparent core loss, the true base of the YBM unit lies at a depth of about 13 ft below mudline (Figure 8). The YBM unit is relatively thin here because it lies in an area where the OBM unit is eroded less than in adjacent areas (see Figures 6 and 7). Estuarine sediments of the YBM unit, associated with sedimentation within Richmond Harbor over the last ~12,000 years, have since covered the eroded OBM surface. As discussed previously, the thinner YBM sequence resulted in significantly less core loss compared with other cores extending to the same depth. Like other sites, the YBM unit consists mostly of a soft, homogeneous, dark-gray, clayey silt. Only the upper half the YBM sequence contains mollusc shells.

A very thick sequence of OBM, totalling 14.2 ft, was penetrated at Station RI-1-TC-4. A significantly higher proportion of sand occurs at this site in comparison with the other Richmond Harbor sites. At the top of the sequence is a firm, cohesive clay containing animal burrows, decayed organic matter, root traces, and mud concretions. These fine-grained sediments grade downward into softer silty and eventually pebbly sand deposits to a depth of 24 ft below mudline. A sedimentary sequence like this is characteristic of deposition within a river basin, where sandy deposits were deposited in the river channel itself while finer-grained deposits formed on the adjacent floodplain. Beneath the pebbly sands lie several alternating layers of firm, compacted clayey silt to silty clay.

Except for the uppermost one foot of the OBM unit, which is a reduced gray, the entire OBM sequence is some shade of oxidized brown. This is significant because it suggests that reduced colors observed within the OBM unit here and elsewhere were probably also once oxidized but were later stained by the overlying dark-colored YBM unit.

Station RI-1-TC-5

The YBM unit extends to a depth of 6.5 ft below mudline, while the true base lies about 9 ft below mudline. Dredging within Richmond Harbor appears to have removed the uppermost 13 to 15 ft of the YBM unit at Station

RI-1-TC-5 (Figure 7). The YBM unit consists mostly of a soft, dark-gray, clayey silt. An exception is an unusual 1.5-ft thick layer of well-graded, light olive-brown sand, which lies in the middle of the YBM unit. This layer is interpreted to represent an event where rapid sediment influx, perhaps from a nearby stream channel during a major flood, occurred within Richmond Harbor.

A total of 10.5 ft of OBM was recovered from RI-1-TC-5. Unlike the OBM unit in RI-1-TC-4, which is dominantly sand, the OBM in RI-1-TC-5 consists exclusively of silt and clay. The reason for this is that RI-1-TC-5 penetrated an area where more floodplain-type sediments were deposited compared with RI-1-TC-4, which is located in an area of mostly channel-fill deposits (see Figure 7). The uppermost 1.5 ft of OBM in RI-1-TC-5 consists of a soft to firm silty clay, which is of marine origin, since it contains mollusc shells. Below this are several alternating layers of terrestrial gray and brown silty clay to clayey silt, containing root fillings and carbonate and iron concretions. At the very bottom of the core is less than 0.5 ft of brown pebbly sand. The consistency of the OBM unit ranges from soft to firm but is particularly hard between the 12- and 14-ft depth below mudline, where it consists of a very compact blue-gray clay.

4.0 ANALYTICAL CHEMISTRY

4.1 INTRODUCTION AND OBJECTIVES

The goal of the analytical chemistry portion of the Richmond Harbor program was to provide reliable data on contaminant concentrations in Richmond Harbor and Santa Fe Channels. Table 2 summarizes the numbers and types of samples and the groups of compounds that were analyzed. The complete list of chemical analytes with proposed detection limits is presented in Tables 3 and 4. Specific objectives of the analytical chemistry were:

1. To analyze all sediment samples from Santa Fe and Richmond Harbor Channels for metals, organotins, base/neutral semivolatile organic compounds, chlorinated pesticides, PCBs, herbicide acids and phenols, oil and grease, and total organic carbon.
2. To measure levels of organophosphorus pesticides and dioxins and furans in sediment samples from 12 Richmond Harbor sites and all Santa Fe Channel composites.
3. To analyze interstitial water and elutriate samples from Santa Fe Channel for metals, organotins, base/neutral semivolatile organic compounds, chlorinated pesticides, PCBs, herbicide acids and phenols, organophosphorus pesticides, and dioxins and furans.

In this section, we review the methods used, any deviations from established protocols, and the quality control and results of each analysis.

4.2 METHODS

4.2.1 Metals in Sediment and Water

Metal concentrations in sediments were determined by one of four procedures, depending on the particular metal and the matrix from which it was extracted and measured. The analyses were conducted by MSL. In sediment samples, arsenic, chromium, copper, nickel, lead, selenium, and zinc were determined by energy-diffusive x-ray fluorescence (XRF) (Nielson and Sanders 1983). Antimony, beryllium, cadmium, silver, and thallium concentrations in sediment were determined by Zeeman graphite-furnace atomic absorption spectroscopy (GFAA) (EPA SW846 7000 Series 1986; Bloom and Crecelius 1983; Bloom and Crecelius 1984b). Mercury in both sediment and water was determined

TABLE 2. Types and Numbers of Samples for Chemical Analyses

		Water		Total
Sample Type	Sediment	Interstitial	Elutriate	Number
Santa Fe Channel	6(a)	3(a)	1.C.3(a)	12(a)
Richmond Harbor Channel				
Short Cores	9(a) 18(b)			9(a) 18(b)
Long Cores	10(a) 12(b)			10(a) 12(b)
Total Each Type	55	3	3	61
Archived Richmond				
Total Cores	16			
Bottoms of Cores	25			
Quality Control Samples				
Duplicates	1(a) 2(b)	0	1(a)*	2(a) 2(b)
Spikes	1(a) 2(b)	1(a)*	0	2(a) 2(b)
SRM	1	1	0	2

(a) Analytical groups for analysis include:
Metals
Butyl Tins
Base/Neutral Semivolatiles
Chlorinated Pesticides/PCBs
Herbicide Acids/Acidic Phenols
Dioxins & Furans
Organophosphorus Pesticides
Total Organic Carbon
Oil and Grease

(b) Analytical groups for analysis include:
Metals
Butyl Tins
Base/Neutral Semivolatiles
Chlorinated Pesticides/PCBs
Herbicide Acids/ Acidic Phenols
Total Organic Carbon
Oil and Grease

* QC samples relevant to both interstitial and elutriate analyses.

TABLE 3. Proposed Detection Limits for Metals, Organotins, Total Organic Carbon, and Oil and Grease

Analyte	Abbreviation	CAS Number*	Proposed Detection Limit Water (μg/L)	Proposed Detection Limit Sediment (μg/g dry)	Crustal Abundance
Arsenic	As	7440-38-2	0.1	2	5
Cadmium	Cd	7440-43-9	0.02	0.05	0.5
Chromium	Cr	7440-47-3	0.2	10	60
Copper	Cu	7440-50-8	0.02	2	20
Lead	Pb	7439-92-1	0.05	2	10
Mercury	Hg	7439-97-6	0.001	0.05	0.1
Nickel	Ni	7440-02-0	0.02	3	30
Silver	Ag	7440-22-4	0.001	0.05	0.1
Zinc	Zn	7440-66-6	2	3	60
Selenium	Se	7782-49-2	2	0.5	1
Antimony	Sb	7440-36-0	2	0.5	1
Thallium	Tl	7440-28-0	2	0.5	1
Beryllium	Be	7440-41-7	2	0.5	1
Organotins			0.05	0.01	N/A
Total Organic Carbon			N/A	0.1%	N/A
Oil and Grease			N/A	20 μg/g dry	N/A

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* CAS Numbers provided for single elements only.
N/A = not applicable.

TABLE 4. Proposed Detection Limits for Organic Compounds (a = Benzidine and 3,3'-dichlorobenzidine are subject to degradative losses during sample workup, qualitative analysis only; b = Phtalates are ubiquitous contaminants in the laboratory environment and may be present in laboratory procedural blanks exceeding detection limits; c = Original plan was to analyze for 2,3,7,8-CDD and 2,3,7,8-CDF. It was mutually agreed in April 1989 that totals would be analyzed instead.)

Compound	CAS Number	Water (µg/L)	Sediment (µg/kg dry wt)
Base/Neutral Semivolatiles by Method 8270			
Acenaphthene	83-32-9	33	100
Acenaphtylene	208-[illegible]-8	33	100
Anthracene	120-12-7	33	100
Benzidine(a)	92-87-5		
Benzo(a)anthracene	56-55-3	33	100
Benzo(b)fluoranthene	205-99-2	33	100
Benzo(k)fluoranthene	207-08-9	33	100
Benzo(a)pyrene	50-32-8	33	100
Benzo(g,h,i)perylene	191-24-2	33	100
Bis(2-chloroethyl)ether	111-44-4	33	100
Bis(2-chloroethoxy)methane	111-91-1	33	100
Bis(2-chloroisopropyl)ether	108-60-1	33	100
Bis(2-ethylhexyl)phthalate(b)	117-81-7	33	100
4-Bromophenyl phenyl ether	101-55-3	33	100
Butyl benzyl phthalate(b)	85-68-7	33	100
2-Chloronaphthalene	91-58-7	33	100
4-Chlorophenyl phenylether	7005-72-3	33	100
Chrysene	218-01-9	33	100
Dibenzo(a,h)anthracene	53-70-3	33	100
Di-n-butylphthalate	84-74-2	33	100
1,2-Dichlorobenzene	95-50-1	33	100
1,3-Dichlorobenzene	541-73-1	33	100
1,4-Dichlorobenzene	106-46-7	33	100
3,3'-Dichlorobenzidine(a)	91-94-1		
Diethylphthalate(b)	84-66-2	33	100
Dimethylphthalate(b)	131-11-3	33	100
2,4-Dinitrotoluene	121-14-2	33	100
2,6-Dinitrotoluene	606-20-2	33	100
Di-n-octylphthalate(b)	117-84-0	33	100
1,2-diphenylhydrazine	122-66-7	33	100
Di-n-propylnitrosoamine	621-64-7	33	100
Fluoranthene	206-44-0	33	100
Fluorene	86-73-7	33	100
Hexachlorobenzene	118-74-1	33	100
Hexachlorobutadiene	87-68-3	33	100
Hexachlorocyclopentadiene	77-47-4	33	100
Hexachloroethane	67-72-1	33	100
Indeno(1,2,3-cd)pyrene	193-39-5	33	100

TABLE 4. (continued)

Compound	CAS Number	Water (μg/L)	Sediment (μg/kg dry wt)
Base/Neutral Semivolatiles (continued)			
Isophorone	78-59-1	33	100
Naphthalene	91-20-3	33	100
Nitrobenzene	98-95-3	33	100
N-Nitrosodimethylamine	62-75-9	33	100
N-Nitrosodiphenylamine	86-30-6	33	100
Phenanthrene	85-01-8	33	100
Pyrene	129-00-0	33	100
Chlorinated Pesticides by Method 8080			
Aldrin	309-00-2	0.05	2.5
Captan	133-06-2	0.50	25
alpha-Chlordane	5103-71-9	0.50	25
gamma-Chlordane	5103-74-2	0.10	5
4,4'-DDD	72-54-8	0.05	2.5
4,4'-DDE	72-55-9	0.05	2.5
4,4'-DDT	50-29-3	0.10	5
Dicofol (Kelthane)	115-32-2	0.10	5
Dieldrin	60-57-1	0.05	2.5
Dinocap	131-72-6	0.10	5
Endosulfan I	959-98-8	0.05	2.5
Endosulfan II	33213-65-9	0.05	2.5
Endosulfan Sulfate	1031-07-8	0.10	5
Endrin	72-20-8	0.05	2.5
Heptachlor	76-44-8	0.05	2.5
alpha-Hexachlorocyclohexane	319-84-6	0.05	2.5
beta-Hexachlorocyclohexane	319-85-7	0.05	2.5
gamma-Hexachlorocyclohexane	58-89-9	0.05	2.5
Methoxychlor	72-43-5	0.20	10
Pentachloronitrobenzene	82-68-8	0.05	2.5
Polychlorinated Biphenyls	1336-36-3	1	50
Toxaphene	8001-35-2	1	50
Organophosphorus Pesticides by Method 8140			
Azinphos-methyl (Guthion)	86-50-0	5	250
Diazinon	333-41-5	5	250
Malathion	121-75-5	5	250
Mevinphos	7786-34-7	5	250
Parathion	56-38-2	5	250
Parathion-methyl	298-00-0	5	250

TABLE 4. (continued)

Compound	CAS Number	Water (µg/L)	Sediment (µg/kg dry wt)
Herbicide Acids and Acidic Phenols by Method 8150			
2,4-D	94-75-7	2	100
2,4-DB	94-82-6	2	100
2,4-Dinitrophenol	51-28-5	0.5	25
Dinoseb (DNOC)	88-85-7	0.5	25
MCPA	94-74-6	20	1000
2-Methyl-4,6-Dinitrophenol (DNOC)	534-52-1	0.5	25
2-Nitrophenol	88-75-5	0.5	25
4-Nitrophenol	100-02-7	0.5	25
Pentachlorophenol	87-86-5	0.5	25
Silvex	93-72-1	0.5	25
2,4-5-T	93-76-5	0.5	25
Dioxins and Furans by Method 8280(c)			
Total Tetra-CDD		0.0002	0.001
Total Penta-CDD		0.0002	0.001
Total Hexa-CDD		0.0002	0.001
Total Hepta-CDD		0.0002	0.001
Total Octa-CDD		0.0002	0.001
Total Tetra-CDF		0.0002	0.001
Total Penta-CDF		0.0002	0.001
Total Hexa-CDF		0.0002	0.001
Total Hepta-CDF		0.0002	0.001
Total Octa-CDF		0.0002	0.001

by cold-vapor atomic absorption spectroscopy (CVAA) using a Laboratory Data Control mercury monitor with a 30-cm cell as a detector (EPA SW846 Method 7471 1986; Bloom and Crecelius 1983). Metal concentrations in water samples were determined by GFAA for all except mercury (determined by CVAA) and arsenic. Arsenic in water was measured using a hydride atomic absorption (HAA) technique following the method of Andreae (1977). The following paragraphs describe the sample preparation steps prior to XRF or atomic absorption analysis.

Sediment samples were freeze-dried and then blended in a Spex mixer-mill. Approximately 5 g of this mixed sediment was then ground in a ceramic-ball mill. A 0.5-g aliquot of dried, ground sediment was sent to Pacific Northwest Laboratory in Richland, Washington, for XRF analysis. This technique is recognized by the National Institute of Standards and Technology (NIST) (formerly National Bureau of Standards) for analyzing metals in sediment matrices. The 0.5 g of freeze-dried sediment was pressed into pellets 2 cm in diameter for XRF analysis following the method of Nielson and Sanders (1983). For atomic absorption (AA) analysis of mercury, cadmium, silver, antimony, beryllium, and thallium, 0.2-g aliquots of the dried homogenate were digested with 4:1 nitric acid:perchloric acid in Teflon digestion bombs and placed in a 130°C oven for 4 h. After these samples cooled, hydrofluoric acid was added to them, after which the digestion bombs were heated in a 130°C oven for 8 to 12 h. Again, samples were allowed to cool thoroughly before a third acid digestion, this one with 20 mL of boric acid for 8 h in the 130°C oven. After cooling, solution volumes were determined and the solutions stored in polyethylene bottles until the analysis, approximately 2 to 3 weeks.

In the final preparation step for interstitial water and elutriate samples (Section 3.5), samples were preserved by acidification with concentrated HCl at a ratio of 1 μL HCl: 1 mL sample. The acidified sample was stored in a Teflon bottle until analysis, approximately 2 to 3 weeks. Analysis of most metals was performed directly on aliquots of this solution. For five metals (cadmium, lead, copper, silver, and nickel), analytical detection in water samples was improved by an additional preparation step. For these five metals, an ammonium pyrrolidinedithiocarbamate (APDC) extraction was carried out on the acidified water sample, after the method of

Bloom and Crecelius (1984a). A 50-mL aliquot of acidified water sample was swirled with 1 mL of 200 ppm cobalt nitrate followed by addition of 1 mL of 2% APDC. This solution stood for at least 30 min before it was vacuum-filtered through a 0.4-μm, Nucleopore polycarbonate filter. Reagent blanks were prepared by adding 1 mL of cobalt nitrate and 1 mL of APDC to a clean filter, letting it stand about 2 min, then filtering. Each filter was folded and placed in an acid-cleaned 17-mL Teflon vial with a Teflon screw cap, 200 μL of concentrated nitric acid (HNO_3) was added, and the uncapped vials were placed on a hot plate at a low setting until the filters had dried. The dried filters were allowed to cool, then 2 mL of 5% HNO_3 was added to each vial and the vial capped and digested in an oven for 2 hr at 75°C.

The acid digestates from sediment samples, acidified water samples, and APDC-extracted water samples were then analyzed by GFAA, CVAA, or HAA for the appropriate metals. Quality control procedures for analysis of metals in sediments and water are covered in Section 4.3.

4.2.2 Organotins in Sediment and Water

Organotin compounds were extracted from the matrix, then analyzed using gas chromatography with flame photometric detection (GC/FPD) following the methods of Unger et al. (1986). Sediment and water samples for organotin analysis were received by the analytical laboratory and stored at 4°C until extraction, approximately 4 weeks. For extraction of organotins from sediment samples, approximately 10 g wet sediment were weighed into a 125-mL solvent-cleaned glass jar. This sediment was mixed thoroughly with approximately 100 g of anhydrous sodium sulfate to remove the water within the sediment. Methylene chloride (110 mL) and 0.25 g of tropolone were then added to the container. This mixture was homogenized for 12 h and the liquid portion decanted through silanized glass wool to remove particles. The container was then rinsed three times with additional $MeCl_2$ and the resulting fluid added to the extract.

Organotins were extracted from water samples by a liquid-liquid separatory-funnel technique. Each sample was extracted three times with 0.2% tropolone in hexane. The mono-, di-, and tri-butyltin compounds extracted from both the sediment and water were derivatized with n-hexyl magnesium bromide to a less volatile and more thermally stable form (nonionic n-hexyl derivatives). The extracts were cleaned up through a Florisil liquid chromatography column and the butyltins quantified by GC/FPD. The concentrations of mono-, di-, and tri-butyltin species are reported. The reported total butyltin concentration is calculated by adding the measured concentration of detected butyltin species and is not a measured total. Quality control measures for organotin analysis are covered in Section 4.3.3.

4.2.3 Organic Compounds in Sediment and Water

Sediment and water samples were analyzed for a variety of organic compounds using standard methods found in EPA SW846 (1986). Three different extraction procedures were conducted on separate aliquots of each field sample. The three extraction procedures with any minor modifications that deviated from the EPA SW846 methods are briefly described below. All sediments were initially extracted within 7 days of core splitting. When analyses for several groups required repeating, samples were shipped in November 1989, approximately 7 months after core splitting. These groups, which were held at 4°C, included semivolatile compounds, chlorinated pesticides/PCBs, herbicide acids and acidic phenols, and a few dioxins/furans. Tests run by NOAA on the length of time samples can be held at this temperature without change in chemistry indicate that samples can be held up to 3 years (Eric Crecelius, personal communication).

Base/Neutral Semivolatiles, Chlorinated Pesticides/PCBs, and Organophosphorus Pesticides

Base/neutral semivolatiles, chlorinated pesticides and PCBs, and organophosphorus pesticides were extracted from sediment using EPA SW846 Method 3540. Analyses of these compounds in water were conducted by Battelle Columbus Division, as were analyses of organophosphorus pesticides in sediments; semivolatiles and chlorinated pesticides/PCBs in sediments were analyzed by Analytical Resources Incorporated. Approximately 50 g of sediment were transferred into a Soxhlet extraction thimble and spiked with surrogate standards and matrix-spike compounds. Samples were extracted overnight in a Soxhlet extractor with 10% methanol in benzene. The solvent was then exchanged to cyclohexane and hexane and this final extract reduced in volume using Kuderna-Danish concentration techniques. Base/neutral compounds, chlorinated and organophosphorus pesticides, and PCBs were isolated from 1-L water samples using separatory funnel liquid-liquid extraction (EPA SW846 Method 3510). Surrogate and matrix-spike compounds were added, and the samples extracted three times into methylene chloride. The extract was dried and concentrated using Kuderna-Danish procedures.

The concentrated extracts from both sediment and water samples were then processed through a liquid chromatography (LC) Phenogel 100-Å size-exclusion column (Phenomenex, Inc.) using methylene chloride as the elution solvent. This extract cleanup procedure is equivalent to EPA SW846 Method 3640. It uses the same quality assurance measures as Method 3640 but allows more efficient separation. The Phenogel LC procedure removes sulfur as well as high-molecular-weight matrix interferences. If necessary, alumina-column cleanup (EPA SW846 Method 3610) was performed to prevent interference with the gas chromatography/nitrogen phosphorous detector (GC/NPD) for organophosphorus pesticides. The extract from the LC procedure or additional cleanup was concentrated to 1 mL using Kuderna-Danish techniques and split into two or three equal portions for analysis of semivolatiles, chlorinated pesticides/PCBs, and organophosphorus pesticides (if required).

Base/neutral semivolatile organic compounds were analyzed by capillary-column gas chromatography with mass spectrometry detection (GC/MS). The list of base/neutral compounds and their characteristic ions is presented in EPA SW846 Method 8270. Chlorinated pesticides and PCBs were analyzed by capillary gas chromatography using electron capture detection (GC/ECD) following analytical and QA guidelines presented in SW846 Method 8080. Method 8080, a packed-column method, was updated for this study, in that a wide-bore capillary column of similar polarity to that suggested in the method was used. The capillary column results in better chromatographic performance than the packed column. Organophosphorus pesticides were analyzed by GC/NPD following analytical and QA guidelines specified in SW846 Method 8140. To give better chromatographic performance, the capillary column was substituted for the packed column of Method 8140 and the gas chromatography conditions adjusted accordingly. As required in the method, analyte identification will be confirmed with a second chromatographic procedure using a column of higher polarity.

Herbicide Acids and Acidic Phenols

Herbicide acids and acidic phenols were extracted from an alkaline sediment slurry, derivatized, processed through a Florisil column, and analyzed by GC/ECD (EPA Method 8150). Analyses of these compounds in water was conducted by Battelle Columbus Division, analysis in sediments by Analytical Resources Incorporated. Sediment samples for herbicide and phenol analysis were prepared for analysis by transferring approximately 50 g of sediment into a 250-mL Teflon jar, adding 50 mL water, and adjusting the pH to >12. The alkaline extraction hydrolyzed organic esters, and interfering base/neutral compounds were removed with a solvent wash. The slurry was then acidified with HCl to pH 4 and appropriate internal recovery standards added. Samples underwent three consecutive extractions on a tumbler with acetone and diethyl ether as the extraction solvents. The extracts were combined and concentrated using Kuderna-Danish techniques to 1 mL. The extract was then esterified (converted to methyl esters) using diazomethane as the derivatizing agent (EPA SW846 Method 8150). The resulting solution was concentrated and processed through a Florisil chromatography column and the clean, derivatized extract reconcentrated for GC/ECD analysis.

Herbicide acids and phenols were isolated from aqueous samples using a liquid-liquid extraction procedure. The pH of the aqueous sample was adjusted to >12 using potassium hydroxide (KOH) to hydrolyze herbicide esters, and interfering organic contaminants were removed with an ether wash. The pH was adjusted to 4, appropriate internal recovery standards were added, and the sample was re-extracted three times with ether. Ether extracts were combined, reduced in volume, derivatized with diazomethane, and reconcentrated for analysis.

Derivatized herbicide acids and phenols from both sediments and water were analyzed by GC/ECD following the guidelines provided by EPA

SW846 Method 8150, except that capillary columns were substituted for the packed columns to give better chromatographic performance.

Polychlorinated Dibenzo-p-dioxins (PCDDs or Dioxins) and Polychlorinated Dibenzofurans (PCDFs or Furans)

Introduction. As indicated in the workplan, all dioxin and furan samples were analyzed by Battelle Columbus Division using Method A, described below. Analyses of sediment samples using Method A resulted in some detection limits exceeding 3 ng/kg for 2,3,7,8-TCDD and TCDF. These high detection limits prevented WES from conducting risk assessment analysis on these compounds. Therefore, WES, the San Francisco District, and MSL decided to re-analyze five selected sediment samples at a different laboratory. The five sediment samples were selected based on locations in Richmond Harbor where contaminants have been accumulating. The second laboratory, Twin Cities Testing, conducted the analyses using Method B, also described below.

Method A for Water Analyses. Sediment samples for PCDDs/PCDFs analysis using EPA Method 8280 were prepared by transferring approximately 50 g of sediment into a soxhlet extraction thimble, spiking with nine isotopically labelled PCDD/PCDF surrogates, and extracting overnight in a soxhlet extractor with 10% methanol in benzene as the extraction solvent. Aqueous samples were extracted by separatory-funnel liquid-liquid extraction with methylene chloride identically to the method for isolating base/neutral compounds. Both sediment and water extracts were submitted to an acid-base washing treatment, dried over sodium sulfate, and concentrated using Kuderna-Danish techniques. Following a solvent exchange to hexane, the extract was cleaned up by column chromatography with acid/base silica and neutral alumina. Following the cleanup step, quantification internal standards were added, and the sample was analyzed by high-resolution capillary chromatography using high-resolution mass spectrometry detection. To achieve lower detection limits, calibrations were done with a 50 ng/mL standard instead of a 500 ng/mL standard. Quantification of the individual congeners, total PCDDs, and total PCDFs was achieved in conjunction with a multipoint calibration curve for each compound, during which each calibration solution was analyzed once. Results are reported as total congener series of PCDDs and PCDFs.

Method B for Sediment Analyses. Twin Cities Testing analyzed sediments according to the following procedure.

- PCDD/PCDF Extraction: A portion of each sample was spiked with $^{13}C_{12}$-labelled PCDD/PCDF internal standards and extracted with benzene in a Soxhlet Dean-Stark extractor. The extracts were quantitatively transferred to Kuderna-Danish concentrators, concentrated, and solvent-exchanged to hexane. The hexane extracts were then spiked with a 2,3,7,8-TCDD-$^{37}C_{14}$ extraction-efficiency standard and processed through the analyte-enrichment procedures described below.

- Analyte Enrichment for PCDD/PCDF Analyses: The extraction procedure often removes from the sample matrix a variety of compounds in addition to the PCDDs and PCDFs. Some of these compounds can directly interfere with the analyses, while others can overload the capillary column, causing degradation in chromatographic resolution or sensitivity. The analyte-enrichment steps were used to remove interferences from the extracts.

  The sample extracts were dissolved in 100 mL of hexane and then transferred to separatory funnels and extracted once with 1-M sodium hydroxide, three times with concentrated sulfuric acid, and once with distilled water. The hexane layers were concentrated with 1 mL and quantitatively transferred to liquid chromatography columns containing alternating layers of silica gel, 44% concentrated sulfuric acid on silica gel, and 33% 1-M sodium hydroxide on silica gel. The columns were eluted with 60 mL of hexane, and each entire eluate was collected and concentrated, under a gentle stream of dry nitrogen, to a volume of 1 mL.

  The extracts were then fractionated on liquid chromatography columns containing 4 g of activated alumina. The columns were eluted with 10 mL of hexane followed by 7 mL of 2.0% methylene chloride/hexane and 25 mL of 60% methylene chloride in hexane. The 60% methylene chloride/hexane fractions were concentrated to 1 mL under a stream of dry nitrogen and applied to the tops of chromatography columns containing 1 g of 5% AX-21 activated carbon on silica gel. Each column was eluted with cyclohexane/methylene chloride (50:50 V/V) and cyclohexane/methanol/benzene (75:20:5 V/V) in the forward direction, and then with benzene in the reverse direction. Each benzene fraction collected was spiked with recovery standards and concentrated to a volume of 20 μl.

- PCDD/PCDF Analyses: Extracts were analyzed for the presence of PCDDs and PCDFs using combined capillary column gas chromatography/high-resolution mass spectrometry (HRGC/HRMS). The instrumentation consisted of a Hewlett Packard Model 5890 gas chromatograph and a VG Model 70SE high-resolution mass spectrometer. The capillary column was interfaced directly into the ion source of the mass spectrometer, providing the highest possible sensitivity while minimizing degradation of the chromatographic resolution.

The mass spectrometer was operated in the electron impact ionization mode at a mass resolution of 10,000 to 11,000. This resolution is sufficient to resolve most interferences, such as PCBs, thus providing the highest level of confidence that the detected levels of PCDD/PCDF are not false positives resulting from interferences.

The data were acquired by selected-ion-recording (SIR) monitoring of the groups of ion masses described in EPA method 8290. The five groups corresponded to the tetrachlorinated through octachlorinated congener classes.

4.2.4 Oil and Grease in Sediment

Total oil and grease concentration in sediment was determined by MSL by infrared spectrophotometry (IR), following Method 502 B (APHA 1985). Oil and grease may include hydrocarbons, fats, fatty acids, soaps, waxes, oils, and any other carbon-hydrogen material extracted by freon solvent. A small aliquot of sample was weighed, dried, and then reweighed to obtain the percent moisture so that results could be reported as dry-weight concentrations. Sediment for oil and grease analysis was extracted by weighing approximately 10 g of sediment into a 250-mL jar rinsed with solvent. Approximately 150 g of anhydrous sodium sulfate was added to the sample and homogenized with the sediment to absorb any water from the sediment. Next, 100 mL of Freon was added and stirred into this mixture. The sample was then immediately homogenized by placing it on a rolling-mill sample homogenizer overnight. After the sample was removed from the roller, the Freon was poured into a solvent-rinsed conical vial. The sample extracts were scanned from 4000 to 600 cm^{-1}, and the peak height measured at 2930 cm^{-1}. This wavelength represents the CH_2 configurations of hydrocarbons and was the standard used to determine oil and grease. The relationship of peak height to the oil concentration was determined by regressing the peak height versus a known concentration of fuel oil (EPA-API Reference Oil WP 681). Oil and grease concentration in sediment is reported in $\mu g/g$ (dry weight).

Results from oil and grease testing were lower than anticipated based on other data for the Richmond Harbor area. Therefore, three oil and grease samples were re-analyzed by MSL. At the same time, an additional method was conducted using a double extraction. As further checks, another laboratory analyzed the same samples using the single- and double-extraction methods and MSL ran a third single extraction. The data generated through inter- and intralaboratory comparisons support the initial results and indicate that the values are correct.

4.2.5 Total Organic Carbon (TOC) in Sediment

Total organic carbon in sediment was determined by Global Geochemistry of Canoga Park, California, following Standard Method 505 (APHA 1985) and PSEP (1986). The carbon dioxide released from the organic carbon during combustion of the sediment was quantified by a LECO WR-12 carbon analyzer. Prior to combustion, hydrochloride was used to release inorganic carbonates from the sediment sample. Total organic carbon is reported as percent dry weight.

4.3 QUALITY CONTROL

Quality control procedures were applied to all categories of chemical analyses. Minimum requirements included analysis of reagent blanks, duplicate analysis of at least 5% of samples, analysis of standard reference materials (SRMs), and analysis of matrix spikes. Reagent blanks were analyzed with every batch of samples in all analyses except for XRF analysis of certain metals and TOC. In XRF and TOC analyses, samples are freeze-dried without additional preparation, making a reagent blank inappropriate.

For every group of analytes (metals, organotins, organic compounds, TOC, oil and grease), three sediment samples and one water sample were duplicated. These numbers represent 5% of 55 sediment samples and 10 water samples (including Sequim Bay), respectively. In analysis of duplicates, the relative percent difference (RPD) and industrial statistic (I) are calculated as follows:

$$\text{RPD} = \frac{|\text{Replicate 1} - \text{Replicate 2}|}{\frac{\text{Replicate 1} + \text{Replicate 2}}{2}} \times 100$$

$$\text{I} = \frac{|\text{Replicate 1} - \text{Replicate 2}|}{\text{Replicate 1} + \text{Replicate 2}}$$

The purpose of duplication is to evaluate the analytical precision of a method. In the case of the Richmond Harbor water samples, no single sample had sufficient volume to yield two aliquots for true duplicate analysis. The water duplicate is a procedural duplicate obtained by carrying two aliquots of sediment composite through the elutriate procedure (Section 3.5.2). Because of the potential variability in the sediment composite and the elutriate procedure, this duplicate cannot be construed to reflect analytical precision.

To assess accuracy of analysis of most metals, SRMs are analyzed along with the samples. Where appropriate to assess accuracy of the method, 5% of samples (three sediment, one water) were spiked with known concentrations of compound and the percent recovery reported. Spiking of 5% of samples was done during analyses involving organotins.

4.3.1 Metals

Sediment

To assess accuracy, SRMs containing known concentrations of the analyte were analyzed with each batch of samples. For sediments, the SRMs were MESS-1 obtained from the National Research Council of Canada (NRCC), and National Bureau of Standards (NBS) SRM-1646. Spike recoveries of Ag and Tl, for which there are no certified values in reference material, were measured to test the accuracy of the method. Three replicates of a standard known to have low concentrations of Ag and Tl (SRM MESS-1, NRCC) were spiked with known amounts of Ag and Tl (0.5 and 2.0 μg/g respectively), digested, and analyzed.

Water

Duplicate analysis was carried out on one sample (5% of 10 total samples). Because a single sample volume was insufficient to split into duplicate aliquots, the water duplicate is a procedural duplicate obtained by carrying two aliquots of sediment composite through the elutriate procedure (Section 3.5.2). To assess analytical accuracy, the standard reference material CASS-1 from NRCC was analyzed at the same time as the Richmond Harbor samples. Accuracy of the As measurement was confirmed by analysis of a second Canadian SRM, NASS-1. However, 5 metals (Ag, Be, Sb, Se, Tl) on the list of analytes had no certified values in these standard reference materials. The accuracy of the measurement of each of these metals, except Ag, was assessed by spike additions at the time of analysis. Silver is a unique analyte in that it undergoes APDC extraction prior to measurement and that no SRM is available with a certified Ag concentration. Therefore, to evaluate the accuracy of Ag analysis, a sample must be spiked prior to the extraction. A standard with low silver concentration (CASS-1, NRCC) was spiked with 0.02 μg/L Ag, carried through the APDC process, and the extracts analyzed.

4.3.2 Organotins

Duplicate analysis was carried out on three sediment samples and 1 water sample. As with metals in water, not enough volume of a single sample was available to do a true duplicate of a water sample. Prior to extraction, each sample was spiked with a known amount of tripropyltin and carried through the extraction process. The percent recovery of tripropyltin is a measure of the efficiency of the organotin extraction. Three sediment samples and one water sample were spiked with a solution of mono-, di-, and tributyltin in known concentrations and the percent recovery reported. At the time the Richmond Harbor samples were analyzed, no standard reference material was available that was certified for butyltins. The laboratory analyzed a sediment (SQ-1, National Oceanic and Atmospheric Administration) for which they have a range of reported tributyltin values. The SQ-1 is not a certified (NBS, NRCC) reference material, but it is regularly run with each batch to assess the reliability of the data.

4.3.3 Organic Compounds

Quality control measures for organic compounds in sediment samples included analysis of 5% (of the total number of samples) method blanks, duplicates, and matrix spikes. One exception is that the duplicate water sample is not a true laboratory duplicate (aliquots of a single sample) but is a separately prepared elutriate from the Santa Fe Channel Reach B (upper) sediment composite. All samples were spiked with surrogate compounds to assess extraction efficiency and the recovery of analyte from the sample matrix. The quality control measures discussed here apply only to assessment of analytical performance, not to the integrity of the samples.

Base/Neutral Semivolatiles

Sediment. At least three blanks were analyzed, three samples were duplicated, and duplicates of three samples were spiked with all base/neutral compounds. The sample duplicates and matrix-spike duplicates were compared using the RPD and I (Section 4.3). Semivolatile surrogate compounds were d5-nitrobenzene, 2-fluorobiphenyl, d14-p-terphenyl, d5-phenol, 2-fluorophenol, and 2,4,6-tribromophenol. The percent recoveries of these compounds reflect the semivolatile extraction efficiency. The percent recovery for the matrix spike of each individual analyte is a measure of analytical accuracy for that analyte.

Water. One method blank was analyzed with the batch of 10 water samples. Because enough of any one water sample was not available to split for a matrix spike, the matrix spike was performed on reagent water. As discussed above, there was not enough of any one water sample to split for duplicate analysis, but two elutriate samples were prepared from the Santa Fe Channel Reach B (upper) sediment composite. These samples are reported as duplicates but are not compared using the RPD and I.

Chlorinated Pesticides and PCBs

Sediment. At least three blanks, three duplicates, and three matrix spikes/matrix-spike duplicates were analyzed with the batch. The matrix-spike solution included all the chlorinated pesticides plus the PCB Aroclor 1242. The sample duplicates are compared using the RPD and I; the matrix-spike duplicates are compared using RPD. All samples were spiked with the surrogate compound dibutylchlorendate (DBC) as specified in SW846 Method 8080 to assess extraction efficiency and the recovery of analyte from the sample matrix.

Duplicates for Station RI-1-C-39 were inconsistent (see Table 18). Therefore, this station was re-analyzed along with several surrounding it to determine 1) whether high values of 4,4'-DDE were present and 2)if so, whether these levels were restricted to that station. Results from these new analyses of chlorinated pesticides/PCBs (also conducted by Analytical Resources

Incorporated) indicated that values of 4,4'-DDE are low at those and adjacent stations (Tables 22 and 23).

Water. One method blank was analyzed, and a matrix spike was conducted on reagent water. All chlorinated pesticides were included in the matrix-spiking solution. Again, the duplicate elutriate samples are reported but not compared as laboratory duplicates. The surrogate compound added to water samples was 1,3-dimethyl-2-nitrobenzene.

Herbicide Acids and Acidic Phenols

Sediment. Quality control procedures for herbicide acids and acidic phenols were similar to those for base/neutral semivolatiles and chlorinated pesticides and PCBs. Sample duplicates are compared using RPD and I; matrix-spike duplicates are compared using RPD.

Water. One method blank was analyzed and a matrix spike including all analytes was conducted on reagent water. The elutriate duplicates are reported but not compared using RPD or I. The surrogate compound used was 2,4-dichlorophenylacetic acid.

Organophosphorus Pesticides

Sediment. Three method blanks, one duplicate (5% of 25 samples), and one matrix spike were analyzed with the sample batch. The duplicate results are compared using RPD and I.

Water. A method blank and reagent-water matrix spike were analyzed with the batch of 10 water samples. All organophosphorus analytes were included in the matrix-spiking solution. The duplicate elutriates were analyzed and reported but not compared using RPD or I.

Dioxins and Furans

Sediment - Method A. For the sediment samples analyzed, three spikes and three blanks were analyzed.

Sediment - Method B. For the five sediment samples re-analyzed, one matrix spike and one blank were analyzed. Isotopically labelled PCDD/PCDF compounds were added to each each sample prior to extraction.

Water - Method A. One method blank was analyzed with the batch, as were the elutriate water duplicates. Isotopically labelled PCDD/PCDF surrogates were added to each sample prior to extraction.

4.3.4 Total Organic Carbon

Three samples were analyzed in duplicate as required for the Richmond Harbor Program. In addition, the laboratory reported the results of seven internal duplicates. A standard reference material (MESS-1, NRCC) was analyzed, but no certified value is available for the percent TOC in the MESS-1 sediment.

4.3.5 Oil and Grease

Procedural blanks were run with each batch (approximately 20) of samples. Duplicate analyses were performed on three samples, and three samples (5% of total) were spiked with known amounts of EPA/API Reference Oil WP 681 and the recoveries reported. There is no standard reference material for oil and grease in a sediment matrix, but the spike recoveries of the known standard provide a measure of the accuracy of the method.

5.0 RESULTS

5.1 Sediments

5.1.1 Metals

The quality control data for analysis of trace metals in sediments is presented in Table 5. The RPD was less than 10% between most duplicates. The only metal with an RPD greater than 10% in all three duplicates was Sb (11%, 17%, 33%), while Tl had two duplicates with RPDs greater than 10% (26%, 29%). Larger RPDs will occur when two low concentrations are compared. In measurements of accuracy, spike recoveries for Ag were within the acceptable range of 80 to 120%. Spike recoveries of Tl were consistently high (140%). Of the analytes with a certified value in an SRM, only Be was outside the certified range of accuracy. The concentration of Be (1.59 μg/g) was within 6% of the certified range (1.7 to 2.1 μg/g) of Be in the SRM. Two of three replicate Ni values fell just outside the range certified in the SRM, each by less than 5%. Data for metals in sediments in Richmond Harbor and in Santa Fe Channels are presented in Tables 6 through 8.

5.1.2 Organotins

In review of organotin quality control data (Table 9), propyltin recoveries were found to be low (less than 50%) in 4 of the 16 samples. In all cases where recoveries of less than 50% occurred, the samples were re-extracted and re-analyzed and data with the highest percent recovery reported. It is thought that the analyte is lost by volatilization during the extraction process. This hypothesis is supported by the results of the butyltin spikes. Good spike recoveries (80 to 100%) of the mixed-butyltin solution indicate that GC/FPD detected what was present in the sample, evidence that loss of analyte (apparent by the low surrogate recoveries) occurs during extraction. Tributyltin concentration in SQ-1 reference sediment (56 ng/g) was within the range of values previously reported for SQ-1 (44 ± 15 ng/g). Data for organotins in sediments are presented in Tables 10 through 12.

Table 5. Quality Control for Metals in Sediments

Station	Concentration (µg/g dry weight)												
	Ag	As	Be	Cd	Cr	Cu	Hg	Ni	Pb	Sb	Se	Tl	Zn
Achieved Detection Limit	0.01	1.2	0.26	0.003	30	3.0	0.018	3.6	3.0	0.17	1.2	0.23	1.8
Duplicates													
RI-1-C-6	0.13	15.0	1.97	0.13	199	46.3	0.299	91.9	18.6	0.77	< 1.2	0.52	99.2
RI-1-C-6	0.11	15.1	2.21	0.14	208	48.5	0.310	86.2	20.8	1.07	< 1.2	0.39	101.0
RPD	17%	0.66%	11%	7.4%	4.4%	5.3%	3.6%	6.4%	11%	33%	NA	29%	1.8%
I	0.08	0.0	0.06	0.04	0	0.03	0.018	0.0	0.1	0.16	NA	0.14	0.0
RI-1-C-19	0.31	15.1	1.77	0.18	174	64.2	0.417	111.3	35.0	0.48	< 1.2	0.65	153.4
RI-1-C-19	0.30	13.7	1.85	0.18	182	64.1	0.418	101.9	32.1	0.57	< 1.2	0.65	144.0
RPD	3.3%	10%	4.4%	0%	4.6%	0.16%	0.24%	8.8%	8.6%	17%	NA	0%	6.3%
I	0.02	0.05	0.02	0	0	0	0.001	0.0	0.0	0.09	NA	0%	0.0
SA-UPPER	0.33	7.3	2.13	0.59	196	66.5	0.444	86.2	40.9	1.07	< 1.1	0.40	139.0
SA-UPPER	0.32	8.9	1.34	0.58	197	66.3	0.426	85.3	42.5	0.96	< 1.1	0.52	146.1
RPD	3.1%	20%	46%	1.7%	0.51%	0.30%	4.1%	1.1%	3.8%	11%	NA	26%	4.9%
I	0.01	0.1	0.23	0.03	0	0.0	0.021	0.0	0.0	0.05	NA	0.13	0.0

NA = Not applicable.
RPD = Relative percent difference.
I = Industrial statistic I.

Table 5. (continued)

Station	Ag	As	Be	Cd	Cr	Cu	Hg	Ni	Pb	Sb	Se	Tl	Zn
	Concentration (µg/g dry weight)												
Spikes (No SRM available)													
Mess-1 Std + Spike	0.51	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3.32	NA
Mess-1 Std	0.079	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.53	NA
Amount Spiked	0.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.0	NA
Percent Recovery	87	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	140	NA
Mess-1 Std + Spike	0.59	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3.32	NA
Mess-1 Std	0.079	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.53	NA
Amount Spiked	0.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.0	NA
Percent Recovery	102	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	140	NA
Mess-1 Std + Spike	0.56	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3.33	NA
Mess-1 Std	0.079	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.53	NA
Amount Spiked	0.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.0	NA
Percent Recovery	96	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	140	NA

NA = Not applicable.

Table 5. (continued)

Station	Ag	As	Be	Cd	Cr	Cu	Hg	Ni	Pb	Sb	Se	Tl	Zn
	Concentration (µg/g dry weight)												
Standard Reference Materials													
SRM Mess-1 Std	NA	10.1	1.59	0.59	60	27.0	0.188	34.3	34.6	0.66	< 1.1	NA	178.3
SRM Mess-1 Std	NA	10.1	-	0.58	71	23.7	0.175	30.7	36.3	-	< 1.2	NA	184
SRM Mess-1 Std	NA	11.4	-	-	65	25.0	0.171	35.5	35.6	-	< 1.2	NA	187.7
Certified	NA	10.6	1.9	0.59	71	25.1	0.171	29.5	34.0	0.73	-	NA	191
Value*	NA	±1.2	±0.2	±0.10	±11	±3.8	±0.014	±2.7	±6.1	±0.08	-	NA	±17
NBS SRM-1646	NA	NA	NA	0.31	NA	NA	NA	NA	NA	NA	NA	NA	NA
Certified	NA	NA	NA	0.36	NA	NA	NA	NA	NA	NA	NA	NA	NA
Value*	NA	NA	NA	±0.07	NA	NA	NA	NA	NA	NA	NA	NA	NA
Procedural Blank	-	-	-	-	-	-	0.051	-	-	0.29	-	-	-
Procedural Blank	-	-	-	-	-	-	0.046	-	-	< 0.17	-	-	-
Procedural Blank	-	-	-	-	-	-	0.051	-	-	-	-	-	-

NA = Not applicable.
- = Data not available.
* "Value" means acceptable range for certified value.

Table 6. Metals in Sediments from Long Cores(a)

Station	Ag	As	Ba	Cd	Cr	Cu	Hg	Ni	Pb	Sb	Se	Tl	Zn
	Concentration (µg/g dry weight)												
Achieved Detection Limit	0.01	1.2	0.26	0.003	30	3.0	0.018	3.6	3.0	0.17	1.2	0.23	1.8
RI-1-W-1	0.15	6.2	1.16	0.38	182	34.8	0.173	69.5	21.8	0.49	<1.1	<0.23	95.7
RI-1-TC-1 1/4	0.08	8.9	0.89	0.22	213	32.0	0.091	82.9	14.6	0.19	1.2	0.52	85.3
RI-1-TC-1 2/4	0.07	9.8	0.89	0.31	220	31.2	0.058	81.7	10.0	< 0.17	<1.1	0.52	84.3
RI-1-TC-1 3/4	0.10	12.2	1.43	0.19	210	42.1	0.082	91.1	8.3	< 0.17	<1.1	0.52	85.0
RI-1-TC-1 4/4	0.04	9.3	1.27	0.03	257	25.3	0.107	60.1	10.1	0.68	<1.1	<0.23	58.2
RI-1-TC-2 1/4	0.10	12.5	1.34	0.16	243	32.0	0.154	75.5	13.8	< 0.17	<1.2	0.39	91.0
RI-1-TC-2 2/4	0.04	9.6	1.50	0.17	265	28.4	0.052	83.7	10.1	< 0.17	<1.2	0.53	78.5
RI-1-TC-2 3/4	0.08	11.6	1.42	0.20	218	35.6	0.066	96.6	9.2	< 0.17	<1.2	0.65	92.7
RI-1-TC-2 4/4	0.05	11.2	1.61	0.27	235	38.6	0.056	104.2	7.3	0.19	<1.1	0.52	102.7
RI-1-TC-3 1/4	0.05	10.0	0.86	0.15	213	23.6	0.056	70.4	8.1	0.19	<1.1	<0.23	72.3
RI-1-TC-3 2/4	0.07	10.2	1.15	0.23	222	33.6	0.063	83.5	7.7	< 0.17	<1.2	0.39	87.0
RI-1-TC-3 3/4	0.03	10.8	1.65	0.15	204	38.3	0.071	93.3	11.5	0.39	<1.1	0.53	83.8
RI-1-TC-3 4/4	0.08	9.2	1.07	1.49	196	22.6	0.096	64.5	10.9	0.38	<1.1	<0.23	51.1
RI-1-TC-4 1/4	0.11	9.9	1.41	0.21	215	36.3	0.106	90.9	15.8	0.19	<1.2	0.52	94.6
RI-1-TC-4 2/4	0.07	11.4	0.86	0.15	269	32.8	0.068	81.0	8.2	< 0.17	<1.2	0.39	74.3
RI-1-TC-4 3/4	0.08	11.7	1.75	0.09	200	33.3	0.093	87.8	10.6	0.77	<1.2	0.52	70.2
RI-1-TC-4 4/4	0.07	10.4	1.42	0.13	192	28.0	0.054	69.9	9.5	0.29	<1.2	0.52	60.8
RI-1-TC-5 1/5	0.27	14.4	1.49	0.23	174	53.1	0.408	89.4	34.7	0.39	<1.2	0.52	141.7
RI-1-TC-5 2/5	0.36	21.8	1.34	0.56	168	59.8	0.858	83.3	28.3	2.30	<1.2	0.52	154.3
RI-1-TC-5 3/5	0.23	13.2	1.59	0.42	255	71.1	0.748	101.8	26.8	1.14	<1.2	0.52	156.0
RI-1-TC-5 4/5	0.05	9.6	1.16	0.19	242	27.4	0.068	56.0	12.2	0.48	<1.2	0.39	54.1
RI-1-TC-5 5/5	0.07	8.5	1.22	0.23	227	22.2	0.072	52.2	8.0	0.38	<1.1	0.39	55.4

(a) Cores were divided into 4 or 5 vertical sections numbered 1 (top of core) through 4 or 5 (bottom of core).

Table 7. Metals in Sediments from Richmond Harbor Channel Short Cores

Station	Concentration (μg/g dry weight) Ag	As	Be	Cd	Cr	Cu	Hg	Ni	Pb	Sb	Se	Tl	Zn
Achieved Detection Limit	0.01	1.2	0.26	0.003	30	3.0	0.018	3.6	3.0	0.17	1.2	0.23	1.8
RI-1-C-1	0.21	11.1	1.67	0.20	199	52.3	0.262	100.2	21.8	0.48	<1.2	0.39	117.8
RI-1-C-3	0.17	11.9	1.54	0.19	185	38.0	0.191	96.6	16.8	0.39	<1.1	0.53	108.3
RI-1-C-5	0.25	11.6	1.34	0.16	191	55.4	0.311	97.3	27.7	0.48	<1.2	0.52	125.0
RI-1-C-6	0.13	15.0	1.97	0.13	199	46.3	0.299	91.9	18.6	0.77	<1.2	0.52	99.2
RI-1-C-8	0.29	14.0	1.83	0.19	178	62.5	0.314	109.2	30.3	0.58	<1.2	0.53	148.1
RI-1-C-10	0.25	14.6	1.63	0.23	201	62.4	0.325	117.8	28.1	0.58	<1.2	0.39	148.6
RI-1-C-11	0.30	13.7	1.81	0.17	184	63.8	0.349	111.6	32.2	0.49	<1.2	0.66	151.4
RI-1-C-12	0.35	13.3	1.75	0.20	185	59.0	0.353	113.0	30.0	0.48	<1.2	0.78	141.5
RI-1-C-14-U	0.29	14.8	1.75	0.13	213	65.9	0.348	110.1	32.2	0.48	<1.2	0.52	148.6
RI-1-C-14-L	0.34	15.0	1.93	0.27	202	74.6	0.360	122.0	34.2	0.67	<1.2	0.52	160.8
RI-1-C-16	0.05	7.3	1.43	0.12	221	20.8	0.110	49.0	8.5	0.29	<1.1	<0.23	47.8
RI-1-C-18	0.23	12.0	0.81	0.18	162	51.7	0.349	91.0	30.8	0.67	<1.2	0.39	121.8
RI-1-C-19	0.31	15.1	1.77	0.18	174	64.2	0.417	111.3	35.0	0.48	<1.2	0.65	153.4
RI-1-C-20	0.16	12.4	0.90	0.18	233	40.2	0.205	74.1	17.0	0.58	<1.1	0.53	95.9
RI-1-C-23	0.07	10.2	1.76	0.14	170	50.7	0.084	106.3	13.4	0.48	<1.2	0.52	91.7
RI-1-C-24	0.14	12.9	1.37	0.21	206	58.4	0.171	111.5	18.0	0.38	<1.2	0.52	116.5
RI-1-C-25	0.21	13.7	1.58	0.20	165	49.4	0.260	103.3	24.4	0.58	<1.1	0.66	119.6
RI-1-C-26	0.27	16.7	1.76	0.22	194	60.2	0.433	96.0	44.0	0.68	<1.1	0.39	153.3
RI-1-C-29	0.17	7.6	1.65	0.69	155	43.1	0.201	81.4	21.2	0.49	<1.2	0.40	107.1
RI-1-C-30	0.13	6.8	2.00	0.56	152	36.5	0.150	76.3	18.8	0.48	<1.1	0.39	90.7
RI-1-C-32	0.33	17.6	1.76	0.26	197	73.2	0.438	118.1	40.2	0.68	<1.2	0.53	165.9
RI-1-C-33	0.10	16.1	1.13	0.62	152	30.4	0.112	72.0	16.9	0.39	<1.2	0.53	73.9
RI-1-C-35	0.15	8.1	1.19	0.29	167	42.6	0.172	88.4	22.8	0.58	<1.1	0.65	109.2
RI-1-C-36	0.41	14.9	1.60	0.41	194	74.1	0.511	108.0	47.6	0.66	<1.2	0.52	177.8
RI-1-C-38	0.38	12.1	1.80	0.46	188	71.7	0.451	114.2	48.8	1.26	<1.2	0.79	173.3
RI-1-C-39	0.15	4.7	2.05	0.40	145	33.6	0.150	73.2	20.8	0.77	<1.2	0.39	78.5
RI-1-C-41	0.15	3.6	1.69	0.45	144	34.3	0.150	67.3	16.8	0.49	<1.1	0.53	78.5

Table 8. Metals in Sediments from Santa Fe Channel

Station	Ag	As	Be	Cd	Cr	Cu	Hg	Ni	Pb	Sb	Se	Tl	Zn
	Concentration (μg/g dry weight)												
Achieved Detection Limit	0.01	1.2	0.26	0.003	30	3.0	0.018	3.6	3.0	0.17	1.2	0.23	1.8
SA-UPPER	0.33	7.3	2.13	0.59	196	66.5	0.444	86.2	40.9	1.07	<1.1	0.46	139.0
SB-UPPER	0.31	10.7	1.43	0.60	178	62.7	0.379	89.8	40.6	0.68	<1.1	0.40	141.3
SC-UPPER	0.35	8.9	1.68	0.67	199	60.9	0.412	85.8	39.4	0.58	<1.1	0.52	137.9
SA-LOWER	0.15	6.2	1.05	0.38	191	38.6	0.195	74.1	22.7	0.58	<1.1	0.39	96.4
SB-LOWER	0.13	6.9	1.27	0.48	156	36.4	0.127	74.3	16.4	0.39	<1.1	0.39	85.9
SC-LOWER	0.14	6.0	1.50	0.81	184	36.7	0.154	70.1	19.1	0.39	<1.1	<0.23	85.9

Table 9. Quality Control for Organotins in Sediments

Station	Propyl Tin % Recovery	Butyltin Concentration (ng/g dry wt)			
		Tri	Di	Mono	Total
Achieved Detection Limit*		1.4	1.8	1.3	NA
Duplicates					
RI-1-C-6	69	< 0.90	2.2	< 0.79	2.2
RI-1-C-6	57	< 1.6	< 1.4	< 1.0	NA
RPD		NA	NA	NA	
I		NA	NA	NA	
RI-1-C-19	59	13	12	1.7	26.7
RI-1-C-19	42	5.1	5.9	< 1.0	11
RPD		90%	68%	NA	
I		0.44	0.34	NA	
SA-UPPER	53	16	19	2.8	37.8
SA-UPPER	48	15	18	3.4	36.4
RPD		6%	5%	19%	
I		0.03	0.02	0.10	
Spikes					
RI-1-C-6	69	< 0.90	2.2	< 0.79	2.2
RI-1-C-6 + Spike	53	104	117	75	NA
Amount Spiked		130	130	130	NA
Percent Recovery		80	88	58	NA
RI-1-C-16	63	< 0.98	< 1.2	< 0.87	NA
RI-1-C-16 + Spike	53	66	56	39	NA
Amount Spiked		88	88	88	NA
Percent Recovery		75	63	45	NA
RI-1-TC-3 2/4	49	< 1.2	< 1.5	< 1.1	NA
RI-1-TC-3 2/4 + Spike	54	113	155	92	NA
Amount Spiked		156	156	156	NA
Percent Recovery		72	99	59	NA

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* Achieved detection limit is based on a 5-g sample. Actual level of detection varies with sample size and moisture content.

NA = not applicable.

RPD = Relative percent difference.

I = Industrial statistic I.

Table 9. (Continued)

Station	Propyl Tin % Recovery	Butyltin Concentration (ng/g dry wt) Tri	Di	Mono	Total
Reference Material					
SQ-1	57	56	< 2.1	< 1.5	56
Procedural Blank-1	44	< 1.4	< 1.8	< 1.3	NA
Procedural Blank-2	82	0.83	0.43	< 1.5	1.3
Procedural Blank-3	84	0.85	< 2.0	3.2	4.05

NA = not applicable.

Table 10. Organotins in Sediments From Long Cores[(a)]

Station	Propyl Tin % Recovery	Butyltin Concentration (ng/g dry wt)			
		Tri	Di	Mono	Total
Achieved Detection Limit*		1.4	1.8	1.3	NA
RI-1-W-1	32	< 1.6	< 1.9	< 1.4	NA
RI-1-TC-1 1/4	48	< 1.3	< 1.6	< 1.1	NA
RI-1-TC-1 2/4	48	< 1.3	< 1.6	< 1.2	NA
RI-1-TC-1 3/4	50	< 1.0	< 1.3	< 1.0	NA
RI-1-TC-1 4/4	55	< 0.98	2.1	2.5	4.6
RI-1-TC-2 1/4	58	2.6	< 1.5	2.2	4.8
RI-1-TC-2 2/4	58	< 1.2	< 1.5	< 1.1	NA
RI-1-TC-2 3/4	51	< 1.3	< 1.6	< 1.1	NA
RI-1-TC-2 4/4	26	< 1.1	< 1.4	< 1.1	NA
RI-1-TC-3 1/4	50	< 1.0	< 1.3	< 0.97	NA
RI-1-TC-3 2/4	49	< 1.2	< 1.5	< 1.1	NA
RI-1-TC-3 3/4	42	< 1.1	< 1.4	< 1.0	NA
RI-1-TC-3 4/4	45	< 1.0	< 1.3	< 0.94	NA
RI-1-TC-4 1/4	52	3.9	< 1.4	< 1.0	3.9
RI-1-TC-4 2/4	64	< 1.1	< 1.4	1.5	1.5
RI-1-TC-4 3/4	54	< 0.94	< 1.2	< 0.90	NA
RI-1-TC-4 4/4	54	2.3	< 1.0	< 0.77	2.3
RI-1-TC-5 1/5	56	10	6.5	3.2	19.7
RI-1-TC-5 2/5	61	< 1.1	< 1.4	1.8	1.8
RI-1-TC-5 3/5	44	< 1.1	< 1.4	1.1	1.1
RI-1-TC-5 4/5	46	< 1.4	< 1.7	< 1.2	NA
RI-1-TC-5 5/5	50	< 1.1	2.2	< 0.94	2.2

(a) Cores were divided into 4 or 5 vertical sections numbered 1 (top of core) to 4 or 5 (bottom of core).

* Achieved detection limit is based on a 5-g sample. Actual level of detection varies with sample size and moisture content.

NA = not applicable.

Table 11. Organotins in Sediments from Richmond Harbor Channel Short Cores

Station	Propyl Tin % Recovery	Butyltin Concentration (ng/g dry wt)			
		Tri	Di	Mono	Total
Achieved Detection Limit*		1.4	1.8	1.3	NA
RI-1-C-1	72	2.6	< 2.0	< 1.5	2.6
RI-1-C-3	54	< 0.98	4.2	< 0.87	4.2
RI-1-C-5	62	3.0	< 1.9	< 1.4	3.0
RI-1-C-6	69	< 0.90	2.2	< 0.79	2.2
RI-1-C-8	26	< 1.6	< 2.1	< 1.6	NA
RI-1-C-10	61	3.6	4.0	< 1.4	7.6
RI-1-C-11	53	5.7	< 2.1	2.7	8.4
RI-1-C-12	39	5.1	2.0	< 1.3	7.1
RI-1-C-14-U	61	< 1.6	< 2.0	< 1.5	NA
RI-1-C-14-L	67	< 1.4	12	3.8	15.8
RI-1-C-16	63	< 0.98	< 1.2	< 0.87	NA
RI-1-C-18	55	2.8	< 1.7	< 1.2	2.8
RI-1-C-19	59	13	12	1.7	26.7
RI-1-C-20	59	< 1.7	< 1.5	< 1.1	NA
RI-1-C-23	53	< 1.7	< 1.4	< 1.0	NA
RI-1-C-24	48	< 1.9	< 1.6	< 1.2	NA
RI-1-C-25	94	5.2	< 2.6	< 1.9	5.2
RI-1-C-26	48	2.0	4.0	< 0.76	6.0
RI-1-C-29	41	< 1.5	2.4	< 0.95	2.4
RI-1-C-30	60	< 1.9	< 1.6	< 1.2	NA
RI-1-C-32	60	9.5	5.1	1.8	16.4
RI-1-C-33	47	< 1.3	< 1.2	< 0.84	NA
RI-1-C-35	50	< 1.8	< 1.5	< 1.1	NA
RI-1-C-36	57	8.3	4.1	< 2.1	12.4
RI-1-C-38	49	4.4	4.4	3.9	12.7
RI-1-C-39	50	< 1.6	< 1.4	< 0.99	NA
RI-1-C-41	48	< 1.4	< 1.2	< 0.86	NA

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* Achieved detection limit is based on a 5-g sample. Actual level of detection varies with sample size and moisture content.

NA = Not applicable.

Table 12. Organotins in Sediments from Santa Fe Channel

Station	Propyl Tin % Recovery	Butyltin Concentrations (ng/g dry wt) Tri	Di	Mono	Total
Achieved Detection Limit*		1.4	1.8	1.3	NA
SA-UPPER	53	16	19	2.8	37.8
SB-UPPER	49	5.6	8.1	2.2	15.9
SC-UPPER	69	10	7.7	4.9	22.6
SA-LOWER	59	3.1	8.1	4.0	15.2
SB-LOWER	52	< 1.3	< 1.6	< 1.1	NA
SC-LOWER	60	6.8	2.8	< 1.1	9.6

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* Achieved detection limit is based on a 5-g sample. Actual level of detection varies with sample size and moisture content.

NA = not applicable.

5.1.3 Organic Compounds

Base/Neutral Semivolatile Compounds

Quality control data for base/neutral semivolatile compounds are presented in Table 13, except for surrogate-recovery data, which are found in Table 14. Station data for base/neutral semivolatile compounds are located in Tables 15 through 17.

Chlorinated Pesticides and PCBs

Quality control data for chlorinated pesticides and PCBs are included in Table 18. Matrix interference with a nearby peak prevented determining spike recoveries for endosulfan sulfate. Original station data for chlorinated pesticides and PCBs are presented in Tables 19 through 21. Reanalyzed data are located in Tables 22 and 23 (see Section 4.3.3).

Herbicide Acids and Acidic Phenols

Table 24 presents the quality control data for herbicide acids and acidic phenols in sediments. Spike recoveries and duplication are reasonable. Station data for these compounds are found in Tables 25 through 27.

Organophosphorus Pesticides

Quality control data for organophosphorus pesticides in sediments are presented in Table 28. Spike recoveries are reasonable, with the exception of Mevinphos, which is low. Surrogate recoveries were also reasonable. Station data for organophosphorus pesticides are located in Tables 29 through 31.

Dioxins and Furans

The quality control results for the five reanalyzed samples are presented in Tables 32 and 33. The concentrations of dioxins and furans in five samples from Richmond Harbor are presented in Table 34. These QC results indicate a low blank and high recoveries for the matrix spike. The recoveries of the 16 internal standards, which were spiked into each sample before extraction, were all acceptable.

Table 13. Quality Control for Base/Neutral Semivolatiles in Sediments (µg/kg dry weight) (U=not detected at given detection limit; J=estimated value, result less than detection limit; B=analyte found in blank as well as sample; M=estimated value, analyte found and confirmed but with low spectral match parameters; T=benzo(b)- plus benzo(k)fluoranthene, peaks cannot be separated; N/A=not applicable).

Station	Bis(2-chloroethyl)ether	1,3-Dichlorobenzene	1,4-Dichlorobenzene	1,2-Dichlorobenzene	Bis(2-chloroisopropyl) ether	N-nitroso-di-n-propylamine	Hexachloroethane	Nitrobenzene
Method Blanks								
1	33U	33U	33U	33U	33U	33U	70U	33U
2	67U	67U	67U	67U	67U	67U	130U	67U
3	33U	33U	33U	33U	33U	33U	70U	33U
4	67U	67U	67U	67U	67U	67U	130U	67U
5	33U	33U	33U	33U	33U	33U	70U	33U
Duplicates								
SB-UPPER	54U	54U	54U	54U	54U	54U	110U	54U
SB-UPPER DUP	48U	48U	48U	48U	48U	48U	97U	48U
RI-1-TC-5 2/5	46U	46U	46U	46U	46U	46U	90U	46U
RI-1-TC-5 2/5 DUP	48U	48U	48U	48U	48U	48U	95U	48U
RI-1-C-39	44U	44U	44U	44U	44U	44U	87U	44U
RI-1-C-39 DUP	38U	38U	38U	38U	38U	38U	76U	38U
Duplicate RPD								
SB-UPPER	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RI-1-TC-5 2/5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RI-1-C-39	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Duplicate I-Stat								
SB-UPPER	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RI-1-TC-5 2/5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RI-1-C-39	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 13. (Continued)

Station	Bis(2-chloro-ethyl)ether	1,3-Dichloro-benzene	1,4-Dichloro-benzene	1,2-Dichloro-benzene	Bis(2-chloro-isopropyl) ether	N-nitroso-di-n-propylamine	Hexa-chloro-ethane	Nitro-benzene
Spike Recovery (%)								
SC-UPPER	50	43	46	50	57	68	40	62
SC-UPPER DUP	47	45	48	48	51	55	41	51
RI-1-TC-3 1/4	40	35	39	39	46	54	31	46
RI-1-TC-3 1/4 DUP	32	35	35	36	39	50	30	33
RI-1-TC-5 1/5	46	52	52	55	57	59	47	43
RI-1-TC-5 1/5 DUP	48	46	47	51	66	63	43	43
Spike Recovery RPD								
SC-UPPER	6.4	4.3	4.1	2.4	11.3	21.4	1.9	18.4
RI-1-TC-3	23.9	2.6	11.2	7.3	16.0	8.8	2.9	32.2
RI-1-TC-5 1/5	4.5	13.0	11.0	6.0	14.3	6.4	7.4	0.7
Spike Recovery I-Stat								
SC-UPPER	[illegible]	0.02	0.02	0.01	0.06	0.11	0.01	0.09
RI-1-TC-3 1/4	0.12	0.01	0.06	0.04	0.08	0.04	0.01	0.16
RI-1-TC-5 1/5	0.02	0.07	0.06	0.04	0.07	0.03	0.04	0.00

Table 13. (Continued)

Station	Isophorone	Bis(2-chloro-ethoxy)-methane	Naphthalene	Hexachloro-butadiene	Hexachloro-cyclo-pentadiene	2-chloro-naphthalene	Dimethyl-phthalate	Acenaphthylene
Method Blanks								
1	33U	33U	33U	70U	170U	33U	33U	33U
2	67U	67U	67U	130U	330U	67U	67U	67U
3	33U	33U	33U	70U	170U	33U	33U	33U
4	67U	67U	67U	130U	330U	67U	67U	67U
5	33U	33U	33U	70U	170U	33U	33U	33U
Duplicates								
SB-UPPER	54U	54U	54U	110U	270U	54U	54U	54U
SB-UPPER DUP	48U	48U	48U	97U	240U	48U	48U	48U
RI-1-TC-5 2/5	46U	46U	46U	90U	230U	46U	46U	46U
RI-1-TC-5 2/5 DUP	48U	48U	48U	95U	240U	48U	48U	48U
RI-1-C-39	44U	44U	44U	87U	220U	44U	44U	44U
RI-1-C-39 DUP	38U	38U	38U	76U	190U	38U	38U	48U
Duplicate RPD								
SB-UPPER	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RI-1-TC-5 2/5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RI-1-C-39	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Duplicate I-Stat								
SB-UPPER	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RI-1-TC-5 2/5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RI-1-C-39	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 13. (Continued)

Station	Isophorone	Bis(2-chloro-ethoxy)-methane	Naphthalene	Hexachloro-butadiene	Hexachloro-cyclo-pentadiene	2-chloro-naphthalene	Dimethyl-phthalate	Acenaphthylene
Spike Recovery (%)								
SC-UPPER	70	75	75	64	18	90	90	97
SC-UPPER DUP	56	61	65	52	10	81	82	87
RI-1-TC-3 1/4	52	60	58	41	18	78	80	85
RI-1-TC-3 1/4 DUP	60	60	57	38	14	67	80	83
RI-1-TC-5 1/5	68	72	74	59	15	77	82	89
RI-1-TC-5 1/5 DUP	64	69	73	56	12	75	80	89
Spike Recovery RPD								
SC-UPPER	22.0	20.3	14.4	21.2	57.5	10.8	9.9	11.3
RI-1-TC-3 1/4	13.0	0.8	2.4	8.0	28.6	14.4	0.0	2.2
RI-1-TC-5 1/5	6.0	4.3	1.2	5.2	22.2	2.4	2.3	0.7
Spike Recovery I-Stat								
SC-UPPER	0.11	0.10	0.07	0.11	0.29	0.05	0.05	0.06
RI-1-TC-3 1/4	0.07	0.00	0.01	0.04	0.14	0.07	0.00	0.01
RI-1-TC-5 1/5	0.03	0.02	0.01	0.03	0.11	0.01	0.01	0.00

Table 13. (Continued)

Station	Acenaphthene	2,4-Dinitro-Toluene	2,6-Dinitro-Toluene	Diethyl-Phthalate	4-Chloro-phenyl-phenylether	Fluorene	N-Nitroso-diphenyl-amine	4-Bromophenyl-phenylether
Method Blanks								
1	33U	170U	170U	33U	33U	33U	33U	33U
2	67U	330U	330U	67U	67U	67U	67U	67U
3	33U	170U	170U	33U	33U	33U	33U	33U
4	67U	330U	330U	67U	67U	67U	67U	67U
5	33U	170U	170U	33U	33U	33U	33U	33U
Duplicates								
SB-UPPER	54U	270U	270U	54U	54U	54U	54U	54U
SB-UPPER DUP	48U	240U	240U	48U	48U	48U	48U	48U
RI-1-TC-5 2/5	46U	230U	230U	46U	46U	46U	46U	46U
RI-1-TC-5 2/5 DUP	48U	240U	240U	48U	48U	48U	48U	48U
RI-1-C-39	44U	220U	220U	44U	44U	44U	44U	44U
RI-1-C-39 DUP	38U	190U	190U	38U	38U	38U	38U	38U
Duplicate RPD								
SB-UPPER	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RI-1-TC-5 2/5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RI-1-C-39	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Duplicate I-Stat								
SB-UPPER	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RI-1-TC-5 2/5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RI-1-C-39	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 13. (Continued)

Station	Acenaphthene	2,4-Dinitro-Toluene	2,6-Dinitro-Toluene	Diethyl-Phthalate	4-Chloro-phenyl-phenylether	Fluorene	N-Nitroso-diphenyl-amine	4-Bromophenyl-phenylether
Spike Recovery (%)								
SC-UPPER	93	79	74	87	89	100	97	86
SC-UPPER DUP	86	71	67	80	80	92	93	80
RI-1-TC-3 1/4	82	70	66	80	78	90	85	77
RI-1-TC-3 1/4 DUP	81	70	66	82	75	89	97	70
RI-1-TC-5 1/5	86	71	65	81	76	93	99	73
RI-1-TC-5 1/5 DUP	87	68	63	80	75	92	99	72
Spike Recovery RPD								
SC-UPPER	7.7	10.3	10.4	8.7	10.0	9.2	4.1	7.9
RI-1-TC-3 1/4	1.1	0.7	0.7	2.8	3.6	1.0	12.5	9.3
RI-1-TC-5 1/5	0.7	4.4	3.3	1.5	1.2	1.6	0.3	1.7
Spike Recovery I-Stat								
SC-UPPER	0.04	0.05	0.05	0.04	0.05	0.05	0.02	0.04
RI-1-TC-3 1/4	0.01	0.00	0.00	0.01	0.02	0.01	0.06	0.05
RI-1-TC-5 1/5	0.00	0.02	0.02	0.01	0.01	0.01	0.00	0.01

Table 13. (Continued)

Station	Hexachloro-benzene	Phenanthrene	Anthracene	Di-n-butyl-phthalate	Fluoranthene	Pyrene	Butyl-benzyl-phthalate	3,3-Dichloro-benzidine
Method Blanks								
1	33U	33U	33U	33U	33U	33U	33U	170U
2	67U	67U	67U	67U	67U	67U	67U	330U
3	33U	33U	33U	33U	33U	33U	33U	170U
4	67U	67U	67U	67U	67U	67U	67U	330U
5	33U	33U	33U	33U	33U	33U	33U	170U
Duplicates								
SB-UPPER	54U	54U	54U	54U	150	230	54U	270U
SB-UPPER DUP	48U	48U	48U	48U	80	150	48U	240U
RI-1-TC-5 2/5	46U	46U	46U	46U	69	100	46U	230U
RI-1-TC-5 2/5 DUP	48U	48U	48U	48U	99	150	48U	240U
RI-1-C-39	44U	44U	44U	44U	44U	49	44U	220U
RI-1-C-39 DUP	38U	38U	38U	38U	38U	52	38U	190U
Duplicate RPD								
SB-UPPER	N/A	N/A	N/A	N/A	60.9	42.1	N/A	N/A
RI-1-TC-5 2/5	N/A	N/A	N/A	N/A	35.7	40.0	N/A	N/A
RI-1-C-39	N/A	N/A	N/A	N/A	N/A	5.9	N/A	N/A
Duplicate I-Stat								
SB-UPPER	N/A	N/A	N/A	N/A	0.30	0.21	N/A	N/A
RI-1-TC-5 2/5	N/A	N/A	N/A	N/A	0.18	0.20	N/A	N/A
RI-1-C-39	N/A	N/A	N/A	N/A	N/A	0.03	N/A	N/A

Table 13. (Continued)

Station	Hexachloro-benzene	Phenanthrene	Anthracene	Di-n-butyl-phthalate	Fluoranthene	Pyrene	Butyl-benzyl-phthalate	3,3-Dichloro-benzidine
Spike Recovery (%)								
SC-UPPER	86	107	97	97	94	92	79	0
SC-UPPER DUP	80	103	92	87	90	85	72	0
RI-1-TC-3 1/4	77	94	86	100	99	88	82	0
RI-1-TC-3 1/4 DUP	78	87	81	99	95	94	91	0
RI-1-TC-5 1/5	80	91	86	91	89	90	82	0
RI-1-TC-5 1/5 DUP	78	92	86	90	88	88	79	0
Spike Recovery RPD								
SC-UPPER	7.4	4.0	4.9	10.0	4.9	7.8	9.7	N/A
RI-1-TC-3 1/4	1.2	6.8	5.8	1.4	4.2	6.5	11.0	N/A
RI-1-TC-5 1/5	2.7	1.0	0.0	0.7	0.3	1.9	4.1	N/A
Spike Recovery I-Stat								
SC-UPPER	0.04	0.02	0.02	0.05	0.02	0.04	0.05	N/A
RI-1-TC-3 1/4	0.01	0.03	0.03	0.01	0.02	0.03	0.06	N/A
RI-1-TC-5 1/5	0.01	0.00	0.00	0.00	0.00	0.01	0.02	N/A

Table 13. (Continued)

Station	Benzo(a)-anthracene	Bis(2-ethylhexyl)-phthalate	Chrysene	Di-n-octyl-phthalate	Benzo(b)-fluoranthene	Benzo(k)-fluoranthene	Benzo(a)-pyrene	Indeno-(1,2,3-CD)-pyrene
Method Blanks								
1	33U	93	33U	33U	33U	33U	33U	33U
2	67U	67U	67U	67U	67U	67U	67U	67U
3	33U	33U	33U	33U	33U	33U	33U	33U
4	67U	67U	67U	67U	67U	67U	67U	67U
5	33U	33U	33U	33U	33U	33U	33U	33U
Duplicates								
SB-UPPER	120	230B	290	54U	160	180	160	73M
SB-UPPER DUP	50M	270	100	48U	190	84	64M	73M
RI-1-TC-5 2/5	46U	63	43J	46U	46M	56M	58M	79M
RI-1-TC-5 2/5 DUP	48U	94	48U	48U	70T	T	54M	53M
RI-1-C-39	44U	180	44U	44U	44U	44U	44U	44U
RI-1-C-39 DUP	38U	160	38U	38U	38U	38U	38U	38U
Duplicate RPD								
SB-UPPER	N/A	N/A	97.4	N/A	17.1	72.7	N/A	N/A
RI-1-TC-5 2/5	N/A	39.5	N/A	N/A	N/A	N/A	N/A	N/A
RI-1-C-39	N/A	11.8	N/A	N/A	N/A	N/A	N/A	N/A
Duplicate I-Stat								
SB-UPPER	N/A	N/A	0.49	N/A	0.09	0.36	N/A	N/A
RI-1-TC-5 2/5	N/A	0.20	N/A	N/A	N/A	N/A	N/A	N/A
RI-1-C-39	N/A	0.06	N/A	N/A	N/A	N/A	N/A	N/A

Table 13. (Continued)

Station	Benzo(a)-anthracene	Bis(2-ethyl-hexyl)-phthalate	Chrysene	Di-n-octyl-phthalate	Benzo(b)-fluoranthene	Benzo(k)-fluoranthene	Benzo(a)-pyrene	Indeno-(1,2,3-CD)-pyrene
Spike Recovery (%)								
SC-UPPER	77	81	99	90	85	88	75	67
SC-UPPER DUP	73	72	93	84	80	95	75	61
RI-1-TC-3 1/4	82	87	89	94	77	95	77	66
RI-1-TC-3 1/4 DUP	84	93	83	98	75	89	74	63
RI-1-TC-5 1/5	75	84	84	88	74	75	68	62
RI-1-TC-5 1/5 DUP	76	79	80	81	72	78	67	62
Spike Recovery RPD								
SC-UPPER	5.4	9.9	6.2	6.6	5.7	6.5	0.5	9.9
RI-1-TC-3 1/4	2.7	6.1	7.4	3.9	3.0	7.4	4.8	4.9
RI-1-TC-5 1/5	0.4	4.9	4.3	8.6	2.4	3.0	1.3	1.4
Spike Recovery I-Stat								
SC-UPPER	0.03	0.05	0.03	0.03	0.03	0.03	0.00	0.05
RI-1-TC-3 1/4	0.01	0.03	0.04	0.02	0.01	0.04	0.02	0.02
RI-1-TC-5 1/5	0.00	0.02	0.02	0.04	0.01	0.02	0.01	0.01

Table 13. (Continued)

Station	Dibenzo(a,h)-anthracene	Benzo(g,h,i)-perylene	Benzidine
Method Blanks			
1	33U	33U	1700U
2	67U	67U	3300U
3	33U	33U	1700U
4	67U	67U	3300U
5	33U	33U	1700U
Duplicates			
SB-UPPER	54U	72	2700U
SB-UPPER DUP	48U	66	2400U
RI-1-TC-5 2/5	46U	63	2300U
RI-1-TC-5 2/5 DUP	48U	62M	2400U
RI-1-C-39	44U	44U	2200U
RI-1-C-39 DUP	38U	38U	1900U
Duplicate RPD			
SB-UPPER	N/A	8.7	N/A
RI-1-TC-5 2/5	N/A	N/A	N/A
RI-1-C-39	N/A	N/A	N/A
Duplicate I-Stat			
SB-UPPER	N/A	0.04	N/A
RI-1-TC-5 2/5	N/A	N/A	N/A
RI-1-C-39	N/A	N/A	N/A

Table 13. (Continued)

Station	Dibenzo(a,h)-anthracene	Benzo(g,h,i)-perylene	Benzidine
Spike Recovery (%)			
SC-UPPER	77	26	N/A
SC-UPPER DUP	70	33	N/A
RI-1-TC-3 1/4	73	45	N/A
RI-1-TC-3 1/4 DUP	64	45	N/A
RI-1-TC-5 1/5	65	56	N/A
RI-1-TC-5 1/5 DUP	65	68	N/A
Spike Recovery RPD			
SC-UPPER	9.9	23.3	N/A
RI-1-TC-3 1/4	12.6	1.0	N/A
RI-1-TC-5 1/5	1.4	17.2	N/A
Spike Recovery I-Stat			
SC-UPPER	0.05	0.12	N/A
RI-1-TC-3 1/4	0.06	0.01	N/A
RI-1-TC-5 1/5	0.01	0.09	N/A

Table 14. Surrogate Recoveries (%) for Base/Neutral Semivolatiles.

STATION	BASE/NEUTRAL SURROGATES d5-Nitrobenzene	BASE/NEUTRAL SURROGATES 2-Fluorobiphenyl	BASE/NEUTRAL SURROGATES d14-p-Terphenyl	ACID SURROGATES d5-Phenol	ACID SURROGATES 2-Fluorophenol	ACID SURROGATES 2,4,6-Tribromophenol
QC LIMIT	23-120	30-115	18-137	24-113	25-121	19-122
METHOD BLANK 1	84.3	93.9	87.3	84.2	66.4	61.6
METHOD BLANK 2	66.6	72.2	88.1	69.8	70.9	65.1
METHOD BLANK 3	83.8	92.7	84.1	79.4	67.3	61.7
METHOD BLANK 4	53.5	59.7	95.0	59.1	59.4	62.3
METHOD BLANK 5	25.4	34.1	65.8	27.5	25.0	30.9
SC UPPER SPIKE	70.7	92.8	83.1	80.4	65.1	74.7
SC UPPER SPIKE DUP	58.0	84.4	75.6	69.3	56.8	72.0
TC-3 1/4 SPIKE	54.4	85.4	82.4	73.6	58.3	72.8
TC-3 1/4 SPIKE DUP	47.6	76.9	83.2	62.6	42.4	60.9
TC-5 1/5 SPIKE	60.9	83.3	80.2	65.4	51.6	61.9
TC-5 1/5 SPIKE DUP	61.2	82.2	81.0	71.2	58.5	60.0
SA UPPER	82.5	100	90.0	87.6	73.6	78.9
SB UPPER	50.5	72.5	74.3	64.0	46.2	68.5
SB UPPER DUP	83.2	102	91.7	87.9	82.7	91.4
SC UPPER	80.0	91.2	82.3	88.9	73.8	70.6
SA LOWER	73.4	87.4	80.7	85.3	72.5	76.6
SB LOWER	60.0	76.2	77.1	73.9	61.2	72.6
SC LOWER	53.1	71.8	70.7	57.4	49.3	65.9
RI-1-W-1	54.4	71.9	72.6	63.2	50.1	59.4
RI-1-TC-1 1/4	68.3	83.6	77.7	81.0	65.6	79.4
RI-1-TC-1 2/4	62.6	79.9	75.5	74.4	60.6	71.3
RI-1-TC-1 3/4	60.9	80.2	76.2	72.8	62.4	72.0
RI-1-TC-1 4/4	64.2	85.7	76.7	76.0	63.8	73.8
RI-1-TC-2 2/4	73.4	85.6	79.7	78.6	63.8	85.9
RI-1-TC-2 3/4	73.6	85.8	79.2	74.8	63.5	84.4
RI-1-TC-2 4/4	69.9	81.9	76.7	70.9	59.8	79.9
RI-1-TC-3 1/4	57.1	64.5	71.5	62.1	65.2	65.2
RI-1-TC-3 2/4	60.8	68.3	101	67.0	68.7	75.2
RI-1-TC-3 3/4	63.5	70.9	88.5	69.9	68.1	78.1
RI-1-TC-3 4/4	64.2	74.4	87.0	71.5	70.5	72.3
RI-1-TC-4 1/4	61.3	70.9	73.0	62.6	58.5	67.7
RI-1-TC-4 2/4	69.0	73.9	72.8	66.8	60.6	67.9
RI-1-TC-4 3/4	71.4	76.1	74.7	68.8	62.0	71.6
RI-1-TC-4 4/4	71.4	80.8	74.4	71.5	60.8	77.6
RI-1-TC-5 1/5	74.6	87.8	86.6	84.5	73.4	77.6
RI-1-TC-5 2/5	73.1	80.2	69.7	71.2	65.7	63.8
RI-1-TC-5 2/5 DUP	83.4	99.6	92.7	92.1	88.2	92.1
RI-1-TC-5 3/5	69.0	71.5	66.0	70.8	59.0	55.6
RI-1-TC-5 4/5	76.5	76.8	72.1	73.1	58.4	45.3
RI-1-TC-5 5/5	71.9	76.7	73.6	63.7	44.7	38.9

Table 14. (Continued)

	BASE/NEUTRAL SURROGATES			ACID SURROGATES		
STATION	d5-Nitrobenzene	2-Fluorobiphenyl	d14-p-Terphenyl	d5-Phenol	2-Fluorophenol	2,4,6-Tribromophenol
QC LIMIT	23-120	30-115	18-115	24-113	25-121	19-122
RI-1-C-1	65.4	77.0	72.7	66.4	57.5	77.7
RI-1-C-3	76.9	90.3	89.9	80.4	73.7	76.6
RI-1-C-5	60.6	76.3	79.4	67.7	60.5	72.1
RI-1-C-6	77.1	95.9	93.6	83.0	78.6	73.2
RI-1-C-8	56.7	77.0	78.3	68.3	58.8	78.7
RI-1-C-10	50.7	70.4	76.3	63.0	56.7	69.6
RI-1-C-11	57.3	68.5	70.9	64.3	58.8	67.0
RI-1-C-12	60.4	74.9	78.5	65.9	62.5	76.7
RI-1-C-14U	57.0	69.6	71.6	67.0	61.2	64.7
RI-1-C-14L	43.2	64.9	68.3	57.9	46.8	63.9
RI-1-C-16	87.5	96.0	92.2	80.3	71.3	49.5
RI-1-C-18	87.1	97.2	89.6	87.5	85.9	79.0
RI-1-C-19	54.1	65.9	67.8	62.7	56.8	61.8
RI-1-C-20	80.6	97.5	93.3	87.3	82.9	81.7
RI-1-C-23	72.4	91.8	89.7	82.1	75.3	80.2
RI-1-C-24	81.4	94.5	89.7	79.6	80.7	87.7
RI-1-C-25	68.6	85.7	88.8	74.3	65.3	79.5
RI-1-C-26	72.6	95.9	92.0	80.5	77.3	83.2
RI-1-C-29	57.2	70.3	70.5	60.9	59.8	68.2
RI-1-C-30	74.2	93.2	94.2	77.8	79.6	86.4
RI-1-C-32	54.8	68.0	76.3	62.8	55.2	71.0
RI-1-C-33	78.7	96.0	87.6	85.8	81.5	89.6
RI-1-C-35	77.6	99.3	93.4	78.1	75.3	93.4
RI-1-C-36	60.0	71.7	70.8	66.0	59.6	68.5
RI-1-C-38	55.0	70.7	68.5	65.5	56.3	68.6
RI-1-C-39	80.7	96.1	89.9	86.4	81.9	87.3
RI-1-C-39 DUP	88.5	99.5	93.5	92.3	81.7	89.9
RI-1-C-41	75.9	96.1	91.2	79.5	74.9	87.7

Table 15. Base/Neutral Semivolatiles in Sediments from Richmond Harbor Channel Long Cores (µg/kg dry weight) (U=not detected at given detection limit; J=estimated value, result less than detection limit; B=analyte found in blank as well as sample; M=estimated value, analyte found and confirmed but with low spectral match parameters; T=benzo(b)- plus benzo(k)fluoranthene, peaks cannot be separated).

Station	Bis(2-chloro-*ethyl)ether*	1,3-Dichloro-*benzene*	1,4-Dichloro-*benzene*	1,2-Dichloro-*benzene*	*Bis(2-chloro-*isopropyl) *ether*	*N-nitroso-*di-n-*propylamine*	*Hexa-*chloro-*ethane*	Nitro-*benzene*
RI-1-W-1	40U	40U	40U	40U	40U	40U	80U	40U
RI-1-TC-1 1/4	47U	47U	47U	47U	47U	47U	90U	47U
RI-1-TC-1 2/4	44U	44U	44U	44U	44U	44U	90U	44U
RI-1-TC-1 3/4	40U	40U	40U	40U	40U	40U	80U	40U
RI-1-TC-1 4/4	31U	31U	31U	31U	31U	31U	60U	31U
RI-1-TC-2 2/4	47U	47U	47U	47U	47U	47U	90U	47U
RI-1-TC-2 3/4	46U	46U	46U	46U	46U	46U	90U	46U
RI-1-TC-2 4/4	51U	51U	51U	51U	51U	51U	100U	51U
RI-1-TC-3 1/4	87U	87U	87U	87U	87U	87U	170U	87U
RI-1-TC-3 2/4	87U	87U	87U	87U	87U	87U	170U	87U
RI-1-TC-3 3/4	96U	96U	96U	96U	96U	96U	190U	96U
RI-1-TC-3 4/4	74U	74U	74U	74U	74U	74U	150U	74U
RI-1-TC-4 1/4	47U	47U	47U	47U	47U	47U	90U	47U
RI-1-TC-4 2/4	42U	42U	42U	42U	42U	42U	80U	42U
RI-1-TC-4 3/4	40U	40U	40U	40U	40U	40U	80U	40U
RI-1-TC-4 4/4	34U	34U	34U	34U	34U	34U	70U	34U
RI-1-TC-5 1/5	64U	64U	64U	64U	64U	64U	130U	64U
RI-1-TC-5 2/5	46U	46U	46U	46U	46U	46U	90U	46U
RI-1-TC-5 3/5	51U	51U	51U	51U	51U	51U	100U	51U
RI-1-TC-5 4/5	36U	36U	36U	36U	36U	36U	70U	36U
RI-1-TC-5 5/5	33U	33U	33U	33U	33U	33U	69U	33U

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Table 15. (Continued)

Station	Isophorone	Bis(2-chloro-ethoxy)-methane	Naphthalene	Hexachloro-butadiene	Hexachloro-cyclo-pentadiene	2-chloro-naphthalene	Dimethyl-phthalate	Acenaphthylene
RI-1-W-1	40U	40U	40U	80U	200U	40U	40U	40U
RI-1-TC-1 1/4	47U	47U	47U	90U	230U	47U	47U	47U
RI-1-TC-1 2/4	44U	44U	44U	90U	220U	44U	44U	44U
RI-1-TC-1 3/4	40U	40U	40U	80U	200U	40U	40U	40U
RI-1-TC-1 4/4	31U	31U	31U	60U	150U	31U	31U	31U
RI-1-TC-2 2/4	47U	47U	47U	90U	240U	47U	47U	47U
RI-1-TC-2 3/4	46U	46U	46U	90U	230U	46U	46U	46U
RI-1-TC-2 4/4	51U	51U	51U	100U	250U	51U	51U	51U
RI-1-TC-3 1/4	87U	87U	87U	170U	430U	87U	87U	87U
RI-1-TC-3 2/4	87U	87U	87U	170U	430U	87U	87U	87U
RI-1-TC-3 3/4	96U	96U	96U	190U	480U	96U	96U	96U
RI-1-TC-3 4/4	74U	74U	74U	150U	370U	74U	74U	74U
RI-1-TC-4 1/4	47U	47U	47U	90U	240U	47U	47U	47U
RI-1-TC-4 2/4	42U	42U	42U	80U	210U	42U	42U	42U
RI-1-TC-4 3/4	40U	40U	40U	80U	200U	40U	40U	40U
RI-1-TC-4 4/4	34U	34U	34U	70U	170U	34U	34U	34U
RI-1-TC-5 1/5	64U	64U	64U	130U	320U	64U	64U	64U
RI-1-TC-5 2/5	46U	46U	46U	90U	230U	46U	46U	46U
RI-1-TC-5 3/5	51U	51U	51U	100U	260U	51U	51U	51U
RI-1-TC-5 4/5	36U	36U	36U	70U	180U	36U	36U	36U
RI-1-TC-5 5/5	33U	33U	33U	60U	160U	33U	33U	33U

Table 15. (Continued)

Station	Acenaphthene	2,4-Dinitro-Toluene	2,6-Dinitro-Toluene	Diethyl-Phthalate	4-Chloro-phenyl-phenylether	Fluorene	N-Nitroso-diphenyl-amine	4-Bromophenyl-phenylether
RI-1-W-1	40U	200U	200U	40U	40U	40U	40U	40U
RI-1-TC-1 1/4	47U	230U	230U	47U	47U	47U	47U	47U
RI-1-TC-1 2/4	44U	220U	220U	44U	44U	44U	44U	44U
RI-1-TC-1 3/4	40U	200U	200U	40U	40U	40U	40U	40U
RI-1-TC-1 4/4	31U	150U	150U	31U	31U	31U	31U	31U
RI-1-TC-2 2/4	47U	240U	240U	47U	47U	47U	47U	47U
RI-1-TC-2 3/4	46U	230U	230U	46U	46U	46U	46U	46U
RI-1-TC-2 4/4	51U	250U	250U	51U	51U	51U	51U	51U
RI-1-TC-3 1/4	87U	430U	430U	87U	87U	87U	87U	87U
RI-1-TC-3 2/4	87U	430U	430U	87U	87U	87U	87U	87U
RI-1-TC-3 3/4	96U	480U	480U	96U	96U	96U	96U	96U
RI-1-TC-3 4/4	74U	370U	370U	74U	74U	74U	74U	74U
RI-1-TC-4 1/4	47U	240U	240U	47U	47U	47U	47U	47U
RI-1-TC-4 2/4	42U	210U	210U	42U	42U	42U	42U	42U
RI-1-TC-4 3/4	40U	200U	200U	40U	40U	40U	40U	40U
RI-1-TC-4 4/4	34U	170U	170U	34U	34U	34U	34U	34U
RI-1-TC-5 1/5	64U	320U	320U	64U	64U	64U	64U	64U
RI-1-TC-5 2/5	46U	230U	230U	46U	46U	46U	46U	46U
RI-1-TC-5 3/5	51U	260U	260U	51U	51U	51U	51U	51U
RI-1-TC-5 4/5	36U	180U	180U	36U	36U	36U	36U	36U
RI-1-TC-5 5/5	33U	160U	160U	33U	33U	33U	33U	33U

Table 15. (Continued)

Station	Hexachloro-benzene	Phenanthrene	Anthracene	Di-n-butyl-phthalate	Fluoranthene	Pyrene	Butyl-benzyl-phthalate	3,3-Dichloro-benzidine
RI-1-W-1	40U	40U	40U	40U	60J	86J	40U	200U
RI-1-TC-1 1/4	47U	47U	47U	47U	47U	47U	47U	230U
RI-1-TC-1 2/4	44U	44U	44U	44U	44U	44U	44U	220U
RI-1-TC-1 3/4	40U	40U	40U	40U	40U	40U	40U	200U
RI-1-TC-1 4/4	31U	31U	31U	31U	31U	31U	31U	150U
RI-1-TC-2 2/4	47U	47U	47U	47U	47U	47U	47U	240U
RI-1-TC-2 3/4	46U	46U	46U	46U	46U	46U	46U	230U
RI-1-TC-2 4/4	51U	51U	51U	51U	51U	51U	51U	250U
RI-1-TC-3 1/4	87U	56M	52M	87U	87U	87U	87U	430U
RI-1-TC-3 2/4	87U	87U	87U	87U	87U	87U	87U	430U
RI-1-TC-3 3/4	96U	96U	96U	96U	96U	96U	96U	480U
RI-1-TC-3 4/4	74U	74U	74U	74U	74U	74U	74U	370U
RI-1-TC-4 1/4	47U	47U	47U	47U	47U	47U	47U	240U
RI-1-TC-4 2/4	42U	42U	42U	42U	42U	42U	42U	210U
RI-1-TC-4 3/4	40U	40U	40U	40U	40U	40U	40U	200U
RI-1-TC-4 4/4	34U	34U	34U	34U	34U	34U	34U	170U
RI-1-TC-5 1/5	64U	72M	64U	64U	170	260	64U	320U
RI-1-TC-5 2/5	46U	46U	46U	46U	69	100	46U	230U
RI-1-TC-5 3/5	51U	51U	51U	51U	51U	51U	51U	260U
RI-1-TC-5 4/5	36U	36U	36U	36U	36U	36U	36U	180U
RI-1-TC-5 5/5	33U	33U	33U	33U	33U	33U	33U	160U

Table 15. (Continued)

Station	Benzo(a)-anthracene	Bis(2-ethylhexyl)-phthalate	Chrysene	Di-n-octyl-phthalate	Benzo(b)-fluoranthene	Benzo(k)-fluoranthene	Benzo(a)-pyrene	Indeno-(1,2,3-CD)-pyrene
RI-1-W-1	40U	73B	40U	40U	50T	T	40U	40U
RI-1-TC-1 1/4	47U	47U	47U	47U	47U	47U	47U	47U
RI-1-TC-1 2/4	44U	44U	44U	44U	44U	44U	44U	44U
RI-1-TC-1 3/4	40U	40U	40U	40U	40U	40U	40U	40U
RI-1-TC-1 4/4	31U	31U	31U	31U	31U	31U	31U	31U
RI-1-TC-2 2/4	47U	870	47U	47U	47U	47U	47U	47U
RI-1-TC-2 3/4	46U	100	46U	46U	46U	46U	46U	46U
RI-1-TC-2 4/4	51U	670	51U	51U	51U	51U	51U	51U
RI-1-TC-3 1/4	87U	87U	87U	87U	87U	87U	87U	87U
RI-1-TC-3 2/4	87U	87U	87U	87U	87U	87U	87U	87U
RI-1-TC-3 3/4	96U	96U	96U	96U	96U	96U	96U	96U
RI-1-TC-3 4/4	74U	74U	74U	74U	74U	74U	74U	74U
RI-1-TC-4 1/4	47U	47U	47U	47U	47U	47U	47U	47U
RI-1-TC-4 2/4	42U	42U	42U	42U	42U	42U	42U	42U
RI-1-TC-4 3/4	40U	35J	40U	40U	40U	40U	40U	40U
RI-1-TC-4 4/4	34U	430	34U	34U	34U	34U	34U	34U
RI-1-TC-5 1/5	76	170	110	64U	200T	T	110J	150
RI-1-TC-5 2/5	46U	63	43J	46U	46M	56M	58M	79M
RI-1-TC-5 3/5	51U	51U	51U	51U	51U	51U	51U	51U
RI-1-TC-5 4/5	36U	110	36U	36U	36U	36U	36U	36U
RI-1-TC-5 5/5	33U	27J	33U	33U	33U	33U	33U	33U

Table 15. (Continued)

Station	Dibenzo(a,h)-anthracene	Benzo(g,h,i)-perylene	Benzidine
RI-1-W-1	40U	40U	2000U
RI-1-TC-1 1/4	47U	47U	2300U
RI-1-TC-1 2/4	44U	44U	2200U
RI-1-TC-1 3/4	40U	40U	2000U
RI-1-TC-1 4/4	31U	31U	1500U
RI-1-TC-2 2/4	47U	47U	2400U
RI-1-TC-2 3/4	46U	46U	2300U
RI-1-TC-2 4/4	51U	51U	2500U
RI-1-TC-3 1/4	87U	87U	4300U
RI-1-TC-3 2/4	87U	87U	4300U
RI-1-TC-3 3/4	96U	96U	4800U
RI-1-TC-3 4/4	74U	74U	3700U
RI-1-TC-4 1/4	47U	47U	2400U
RI-1-TC-4 2/4	42U	42U	2100U
RI-1-TC-4 3/4	40U	40U	2000U
RI-1-TC-4 4/4	34U	34U	1700U
RI-1-TC-5 1/5	64U	100	3200U
RI-1-TC-5 2/5	46U	63	2300U
RI-1-TC-5 3/5	51U	51U	2600U
RI-1-TC-5 4/5	36U	36U	1800U
RI-1-TC-5 5/5	33U	33U	1600U

Table 16. Semivolatile Compounds in Sediments from Richmond Harbor Channel Short Cores (µg/kg dry weight) (U=not detected at given detection limit; J=estimated value, result less than detection limit; B=analyte found in blank as well as sample; M=estimated value, analyte found and confirmed but with low spectral match parameters; T=benzo(b)- plus benzo(k)fluoranthene, peaks cannot be separated).

Station	Bis(2-chloroethyl)ether	1,3-Dichlorobenzene	1,4-Dichlorobenzene	1,2-Dichlorobenzene	Bis(2-chloroisopropyl) ether	N-nitroso-di-n-propylamine	Hexachloroethane	Nitrobenzene
RI-1-C-1	51U	51U	51U	51U	51U	51U	100U	51U
RI-1-C-3	51U	51U	51U	51U	51U	51U	100U	51U
RI-1-C-5	62U	62U	62U	62U	62U	62U	120U	62U
RI-1-C-6	51U	51U	51U	51U	51U	51U	100U	51U
RI-1-C-8	59U	59U	59U	59U	59U	59U	120U	59U
RI-1-C-10	57U	57U	57U	57U	57U	57U	110U	57U
RI-1-C-11	59U	59U	59U	59U	59U	59U	120U	59U
RI-1-C-12	68U	68U	68U	68U	68U	68U	140U	68U
RI-1-C-14U	71U	71U	71U	71U	71U	71U	140U	71U
RI-1-C-14L	63U	63U	63U	63U	63U	63U	130U	63U
RI-1-C-16	34U	34U	34U	34U	34U	34U	70U	34U
RI-1-C-18	57U	57U	57U	57U	57U	57U	110U	57U
RI-1-C-19	63U	63U	63U	63U	63U	63U	130U	63U
RI-1-C-20	46U	46U	46U	46U	46U	46U	90U	46U
RI-1-C-23	51U	51U	51U	51U	51U	51U	100U	51U
RI-1-C-24	56U	56U	56U	56U	56U	56U	110U	56U
RI-1-C-25	53U	53U	53U	53U	53U	53U	110U	53U
RI-1-C-26	57U	57U	57U	57U	57U	57U	110U	57U
RI-1-C-29	44U	44U	44U	44U	44U	44U	90U	44U
RI-1-C-30	39U	39U	39U	39U	39U	39U	80U	39U
RI-1-C-32	73U	73U	73U	73U	73U	73U	150U	73U
RI-1-C-33	40U	40U	40U	40U	40U	40U	81U	40U
RI-1-C-35	45U	45U	45U	45U	45U	45U	91U	45U
RI-1-C-36	58U	58U	58U	58U	58U	58U	120U	58U
RI-1-C-38	59U	59U	59U	59U	59U	59U	120U	59U
RI-1-C-39	44U	44U	44U	44U	44U	44U	87U	44U
RI-1-C-41	40U	40U	40U	40U	40U	40U	80U	40U

Table 16. (Continued)

Station	Isophorone	Bis(2-chloro-ethoxy)-methane	Naphthalene	Hexachloro-butadiene	Hexachloro-cyclo-pentadiene	2-chloro-naphthalene	Dimethyl-phthalate	Acenaphthylene
RI-1-C-1	51U	51U	51U	100U	250U	51U	51U	51U
RI-1-C-3	51U	51U	51U	100U	260U	51U	51U	51U
RI-1-C-5	62U	62U	62U	120U	310U	62U	62U	62U
RI-1-C-6	51U	51U	51U	100U	250U	51U	51U	51U
RI-1-C-8	59U	59U	59U	120U	300U	59U	59U	59U
RI-1-C-10	57U	57U	57U	110U	280U	57U	57U	57U
RI-1-C-11	59U	59U	59U	120U	290U	59U	59U	59U
RI-1-C-12	68U	68U	68U	140U	340U	68U	68U	68U
RI-1-C-14U	71U	71U	71U	140U	350U	71U	71U	71U
RI-1-C-14L	63U	63U	63U	130U	310U	63U	63U	63U
RI-1-C-16	34U	34U	34U	70U	170U	34U	34U	34U
RI-1-C-18	57U	57U	57U	110U	280U	57U	57U	57U
RI-1-C-19	63U	63U	63U	130U	310U	63U	63U	63U
RI-1-C-20	46U	46U	46U	90U	230U	46U	46U	46U
RI-1-C-23	51U	51U	51U	100U	260U	51U	51U	51U
RI-1-C-24	56U	56U	56U	110U	280U	56U	56U	56U
RI-1-C-25	53U	53U	53U	110U	260U	53U	53U	53U
RI-1-C-26	57U	57U	57U	110U	280U	57U	57U	57U
RI-1-C-29	44U	44U	44U	90U	220U	44U	44U	44U
RI-1-C-30	39U	39U	39U	80U	190U	39U	39U	39U
RI-1-C-32	73U	73U	73U	150U	360U	73U	73U	73U
RI-1-C-33	40U	40U	40U	81U	200U	40U	40U	40U
RI-1-C-35	45U	45U	45U	91U	230U	45U	45U	45U
RI-1-C-36	58U	58U	58U	120U	290U	58U	58U	58U
RI-1-C-38	59U	59U	59U	120U	290U	59U	59U	59U
RI-1-C-39	44U	44U	44U	87U	220U	44U	44U	44U
RI-1-C-41	40U	40U	40U	80U	200U	40U	40U	40U

Table 16. (Continued)

Station	Acenaphthene	2,4-Dinitro-Toluene	2,6-Dinitro-Toluene	Diethyl-Phthalate	4-Chloro-phenyl-phenylether	Fluorene	N-Nitroso-diphenyl-amine	4-Bromophenyl-phenylether
RI-1-C-1	51U	250U	250U	51U	51U	51U	51U	51U
RI-1-C-3	51U	260U	260U	51U	51U	51U	51U	51U
RI-1-C-5	62U	310U	310U	62U	62U	62U	62U	62U
RI-1-C-6	51U	250U	250U	51U	51U	51U	51U	51U
RI-1-C-8	59U	300U	300U	59U	59U	59U	59U	59U
RI-1-C-10	57U	280U	280U	47M	57U	57U	57U	57U
RI-1-C-11	59U	290U	290U	59U	59U	59U	59U	59U
RI-1-C-12	68U	340U	340U	68U	68U	68U	68U	68U
RI-1-C-14U	71U	350U	350U	71U	71U	71U	71U	71U
RI-1-C-14L	63U	310U	310U	63U	63U	63U	63U	63U
RI-1-C-16	34U	170U	170U	34U	34U	34U	34U	34U
RI-1-C-18	57U	280U	280U	57U	57U	57U	57U	57U
RI-1-C-19	63U	310U	310U	63U	63U	63U	63U	63U
RI-1-C-20	46U	230U	230U	46U	46U	46U	46U	46U
RI-1-C-23	51U	260U	260U	51U	51U	51U	51U	51U
RI-1-C-24	56U	280U	280U	56U	56U	56U	56U	56U
RI-1-C-25	53U	260U	260U	53U	53U	53U	53U	53U
RI-1-C-26	57U	280U	280U	57U	57U	57U	57U	57U
RI-1-C-29	44U	220U	220U	44U	44U	44U	44U	44U
RI-1-C-30	39U	190U	190U	39U	39U	39U	39U	39U
RI-1-C-32	73U	360U	360U	73U	73U	73U	73U	73U
RI-1-C-33	40U	200U	200U	40U	40U	40U	40U	40U
RI-1-C-35	45U	230U	230U	45U	45U	45U	45U	45U
RI-1-C-36	58U	290U	290U	58U	58U	58U	58U	58U
RI-1-C-38	59U	290U	290U	59U	59U	59U	59U	59U
RI-1-C-39	44U	220U	220U	44U	44U	44U	44U	44U
RI-1-C-41	40U	200U	200U	40U	40U	40U	40U	40U

Table 16. (Continued)

Station	Hexachloro-benzene	Phenanthrene	Anthracene	Di-n-butyl-phthalate	Fluoranthene	Pyrene	Butyl-benzyl-phthalate	3,3-Dichloro-benzidine
RI-1-C-1	51U	140	51	51U	220	300	51U	250U
RI-1-C-3	51U	51U	51U	51U	59	90	51U	260U
RI-1-C-5	62U	110	62U	62U	230	310	62U	310U
RI-1-C-6	51U	51U	51U	51U	58	90	51U	250U
RI-1-C-8	59U	100	59U	59U	210	280	59U	300U
RI-1-C-10	57U	64	57U	57U	130	190	57U	280U
RI-1-C-11	59U	60M	59U	59U	140	220	59U	290U
RI-1-C-12	68U	68	68U	68U	150	230	68U	340U
RI-1-C-14U	71U	71U	71U	71U	150	190	71U	350U
RI-1-C-14L	63U	54M	63U	63U	110	170	63U	310U
RI-1-C-16	34U	34U	34U	34U	34U	34U	34U	170U
RI-1-C-18	57U	78M	57U	57U	140	200	57U	280U
RI-1-C-19	63U	58M	63U	63U	130	170	63U	310U
RI-1-C-20	46U	46U	46U	46U	71	110	46U	230U
RI-1-C-23	51U	51U	51U	51U	51U	51U	51U	260U
RI-1-C-24	56U	56U	56U	56U	56U	56U	56U	280U
RI-1-C-25	53U	53U	53U	53U	65	110	53U	260U
RI-1-C-28	57U	97	57U	57U	170	310	57U	280U
RI-1-C-29	44U	44U	44U	44U	44U	44U	44U	220U
RI-1-C-30	39U	39U	39U	39U	39U	39U	39U	190U
RI-1-C-32	73U	64M	73U	73U	120	200	73U	360U
RI-1-C-33	40U	40U	40U	40U	40U	40U	40U	200U
RI-1-C-35	45U	45U	45U	45U	45U	76	45U	230U
RI-1-C-36	58U	58J	58U	58U	110	240	58U	290U
RI-1-C-38	59U	69M	59U	59U	120	310	59U	290U
RI-1-C-39	44U	44U	44U	44U	44U	49	44U	220U
RI-1-C-41	40U	40U	40U	40U	40U	40M	40U	200U

Table 16. (Continued)

Station	Benzo(a)-anthracene	Bis(2-ethyl-hexyl)-phthalate	Chrysene	Di-n-octyl-phthalate	Benzo(b)-fluoranthene	Benzo(k)-fluoranthene	Benzo(a)-pyrene	Indeno-(1,2,3-CD)-pyrene
RI-1-C-1	84	460	110	51U	150T	T	110	81
RI-1-C-3	51U	51U	51U	51U	51U	51U	51U	51U
RI-1-C-5	110	490	160	52U	220T	T	160	110
RI-1-C-6	51U	250	51U	51U	51U	51U	51U	51U
RI-1-C-8	82M	180	110	59U	190T	T	120	100
RI-1-C-10	60M	370	77M	57U	150T	T	90	70M
RI-1-C-11	56M	250	91M	59U	160T	T	100	70M
RI-1-C-12	67M	510	100M	68U	170T	T	110	89
RI-1-C-14U	64M	200	84	71U	150T	T	93	79M
RI-1-C-14L	63U	310	59M	63U	120T	T	70M	63U
RI-1-C-16	34U	170	34U	34U	34U	34U	34U	34U
RI-1-C-18	62M	440	72M	57U	120T	T	75M	73M
RI-1-C-19	55M	330	75M	63U	140T	T	87	79
RI-1-C-20	46U	310	46U	46U	70MT	T	46U	46U
RI-1-C-23	51U	310	51U	51U	51U	51U	51U	51U
RI-1-C-24	56U	100	56U	56U	56U	56U	56U	56U
RI-1-C-25	53U	53U	53U	53U	53U	53U	57	53U
RI-1-C-26	74M	240	100	57U	94T	T	120M	110
RI-1-C-29	44U	220	44U	44U	44U	44U	44U	44U
RI-1-C-30	39U	130	39U	39U	39U	39U	39U	39U
RI-1-C-32	73U	340	73U	73U	180T	T	99	84M
RI-1-C-33	40U	100	40U	40U	40U	40U	40U	40U
RI-1-C-35	45U	170	45U	45U	61T	T	45U	45U
RI-1-C-36	67M	740	120	58U	200T	T	96	74
RI-1-C-38	70M	560	120	59U	140T	T	140	110
RI-1-C-39	44U	180	44U	44U	44U	44U	44U	44U
RI-1-C-41	40U	270	40U	40U	40U	40U	40U	40U

Table 16. (Continued)

Station	Dibenzo(a,h)-anthracene	Benzo(g,h,i)-perylene	Benzidine
RI-1-C-1	51U	90	2500U
RI-1-C-3	51U	51U	2600U
RI-1-C-5	62U	100	3100U
RI-1-C-6	51U	51U	2500U
RI-1-C-8	59U	97	3000U
RI-1-C-10	57U	62	2800U
RI-1-C-11	59U	77M	2900U
RI-1-C-12	68U	81	3400U
RI-1-C-14U	71U	74	3500U
RI-1-C-14L	63U	59M	3100U
RI-1-C-16	34U	34U	1700U
RI-1-C-18	57U	76M	2800U
RI-1-C-19	63U	62	3199U
RI-1-C-20	46U	46U	2300U
RI-1-C-23	51U	51U	2600U
RI-1-C-24	56U	56U	2800U
RI-1-C-25	53U	65	2600U
RI-1-C-26	57U	110	2800U
RI-1-C-29	44U	44U	2200U
RI-1-C-30	39U	39U	1900U
RI-1-C-32	73U	84	3600U
RI-1-C-33	40U	40U	2000U
RI-1-C-35	45U	45U	2300U
RI-1-C-36	58U	68	2900U
RI-1-C-38	59U	89	2900U
RI-1-C-39	44U	44U	2200U
RI-1-C-41	40U	40U	2000U

Table 17. Base/Neutral Semivolatiles in Sediments from Santa Fe Channel ($\mu g/kg$ dry weight) (U=not detected at given detection limit; J=estimated value, result less than detection limit; B=analyte found in blank as well as sample; M=estimated value, analyte found and confirmed but with low spectral match parameters; T=benzo(b)- plus benzo(k)fluoranthene, peaks cannot be separated).

Station	Bis(2-chloroethyl)ether	1,3-Dichlorobenzene	1,4-Dichlorobenzene	1,2-Dichlorobenzene	Bis(2-chloroisopropyl) ether	N-nitrosodi-n-propylamine	Hexachloroethane	Nitrobenzene
SA UPPER	56U	56U	56U	56U	56U	56U	110U	56U
SB UPPER	54U	54U	54U	54U	54U	54U	110U	54U
SC UPPER	61U	61U	61U	61U	61U	61U	120U	61U
SA LOWER	38U	38U	38U	38U	38U	38U	80U	38U
SB LOWER	40U	40U	40U	40U	40U	40U	80U	40U
SC LOWER	38U	38U	38U	38U	38U	38U	80U	38U

Station	Isophorone	Bis(2-chloroethoxy)-methane	Naphthalene	Hexachlorobutadiene	Hexachlorocyclopentadiene	2-chloronaphthalene	Dimethylphthalate	Acenaphthylene
SA UPPER	56U	56U	56U	110U	280U	56U	56U	56U
SB UPPER	54U	54U	54U	110U	270U	54U	54U	54U
SC UPPER	61U	61U	61U	120U	310U	61U	61U	61U
SA LOWER	38U	38U	38U	80U	190U	38U	38U	38U
SB LOWER	40U	40U	40U	80U	200U	40U	40U	40U
SC LOWER	38U	38U	38U	80U	190U	38U	38U	38U

Table 17. (Continued)

Station	Acenaphthene	2,4-Dinitro-Toluene	2,6-Dinitro-Toluens	Diethyl-Phthalate	4-Chloro-phenyl-phenylether	Fluorene	N-Nitroso-diphenyl-amine	4-Bromophenyl-phenylether
SA UPPER	56U	280U	280U	56U	56U	56U	56U	56U
SB UPPER	54U	270U	270U	54U	54U	54U	54U	54U
SC UPPER	61U	310U	310U	61U	61U	61U	61U	61U
SA LOWER	38U	190U	190U	38U	38U	38U	38U	38U
SB LOWER	40U	200U	200U	40U	40U	40U	40U	40U
SC LOWER	38U	190U	190U	38U	38U	38U	38U	38U

Station	Hexachloro-benzene	Phenanthrene	Anthracene	Di-n-butyl-phthalate	Fluoranthene	Pyrene	Butyl-benzyl-phthalate	3,3-Dichloro-benzidine
SA UPPER	56U	110	57	56U	180	350	56U	280U
SB UPPER	54U	54U	54U	54U	150	230	54U	270U
SC UPPER	61U	61U	61U	61U	72	120	61U	310U
SA LOWER	38U	38U	38U	38U	28J	60	38U	190U
SB LOWER	40U	40U	40U	40U	40U	38J	40U	200U
SC LOWER	38U	38U	38U	38U	23J	36J	38U	190U

Table 17. (Continued)

Station	Benzo(a)-anthracene	Bis(2-ethyl-hexyl)-phthalate	Chrysene	Di-n-octyl-phthalate	Benzo(b)-fluoranthene	Benzo(k)-fluoranthene	Benzo(a)-pyrene	Indeno-(1,2,3-CD)-pyrene
SA UPPER	110	520B	210	54U	210	230	180	120
SB UPPER	120	230B	290	54U	160	180	160	73M
SC UPPER	72M	230	100M	61U	120	100	99	64M
SA LOWER	38U	160B	37M	38U	110T	T	47	43M
SB LOWER	40U	150B	40U	40U	76T	T	36M	40U
SC LOWER	38U	87B	40M	38U	83T	T	36M	38U

Station	Dibenzo(a,h)-anthracene	Benzo(g,h,i)-perylene	Benzidine
SA UPPER	56U	110	2600U
SB UPPER	54U	72	2700U
SC UPPER	61U	93M	3100U
SA LOWER	38U	48M	1900U
SB LOWER	40U	[illegible]	2000U
SC LOWER	38U	[illegible]	1900U

Table 18. Quality Control for Chlorinated Pesticides and PCBs in Sediments (ug/kg dry weight) (N/A = Not applicable, U = compound analyzed, but not detected at given detection limit, J = Estimated value when result is below specified detection limit, MI = Matrix Interference from Unidentified Compounds, * = Indeterminable, below level found in sample - see Table 21)

Station	Surrogate Recovery (%)	Alpha BHC	Beta BHC	Delta BHC	Gamma BHC	Heptachlor	Aldrin	Heptachlor Epoxide	Endo-sulfan I	Dieldrin	4,4'-DDE	Endrin	Endo-sulfan II
Method Blanks													
1	72	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
2	73	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
3	88	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
Duplicates													
SB-UPPER	72	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	8.0	18	2.5U	2.5U
SB-UPPER DUP	79	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	5.3	13	2.5U	2.5U
RI-1-TC-5 2/5	90	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-TC-5 2/5 DUP	77	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-C-39	80	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	7.5	2.5U	2.5U
RI-1-C-39 DUP	82	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
Duplicate RPD													
SB-UPPER		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	41	32	N/A	N/A
RI-1-TC-5 2/5		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RI-1-C-39		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Duplicate I-Stat													
SB-UPPER		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	.20	.16	N/A	N/A
RI-1-TC-5 2/5		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RI-1-C-39		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spike Recovery (%)													
SC-UPPER	73	81	78	79	85	75	75	78	76	71	74	83	78
SC-UPPER DUP	87	98	91	98	103	93	95	91	89	92	102	103	93
RI-1-TC-3 1/4	89	104	89	80	107	96	96	97	92	88	81	102	78
RI-1-TC-3 1/4 DUP	92	101	94	88	108	94	94	98	94	90	84	104	86
RI-1-TC-5 1/5	83	93	83	85	95	86	86	88	82	83	80	92	83
RI-1-TC-5 1/5 DUP	94	107	92	102	110	98	101	99	91	92	90	107	97
Spike Recovery RPD													
SC-UPPER		19	15	21	19	21	24	15	16	26	32	22	18
RI-1-TC-3 1/4		2.9	5.5	9.5	0.9	2.1	2.1	1.0	2.2	2.2	3.6	1.9	9.8
RI-1-TC-5 1/5		14	10	18	15	13	16	12	10	10	12	15	19
Spike Recovery I-Stat													
SC-UPPER		.09	.07	.11	.18	.11	.12	.07	.08	.12	.16	.11	.09
RI-1-TC-3 1/4		.01	.03	.05	.005	.01	.01	.005	.01	.01	.02	.01	.05
RI-1-TC-5 1/5		.17	.05	.09	.07	.07	.08	.06	.05	.05	.06	.08	.08

Table 18. (Continued)

Station	Surrogate Recovery (%)	4,4'-DDD	Endosulfan Sulfate	4,4'-DDT	Methoxy-chlor	Endrin Ketone	Gamma-Chlordane	Alpha-Chlordane	Pentachloro-nitrobenzene	Kelthane	Captan
Method Blanks											
1	72	2.5U	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
2	73	2.5U	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
3	88	2.5U	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
Duplicates											
SB-UPPER	72	190	5.0U	130	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
SB-UPPER DUP	79	120	5.0U	110	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-TC-5 2/5	90	2.5U	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-TC-5 2/5 DUP	77	2.5U	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-C-39	80	32	5.0U	310	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-C-39 DUP	82	17	5.0U	2.2J	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
Duplicate RPD											
SB-UPPER		45	N/A	17	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RI-1-TC-5 2/5		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RI-1-C-39		61	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Duplicate I-Stat											
SB-UPPER		.06	N/A	.08	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RI-1-TC-5 2/5		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RI-1-C-39		.31	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spike Recovery (%)											
SC-UPPER	73	131	NI	*	78	N/A	N/A	N/A	N/A	N/A	N/A
SC-UPPER DUP	87	230	NI	*	95	N/A	N/A	N/A	N/A	N/A	N/A
RI-1-TC-3 1/4	89	90	NI	92	96	N/A	N/A	N/A	N/A	N/A	N/A
RI-1-TC-3 1/4 DUP	92	92	NI	95	101	N/A	N/A	N/A	N/A	N/A	N/A
RI-1-TC-5 1/5	83	87	NI	87	90	N/A	N/A	N/A	N/A	N/A	N/A
RI-1-TC-5 1/5 DUP	94	105	NI	76	102	N/A	N/A	N/A	N/A	N/A	N/A
Spike Recovery RPD											
SC-UPPER		56	N/A	N/A	20	N/A	N/A	N/A	N/A	N/A	N/A
RI-1-TC-3 1/4		2.2	N/A	3.2	5.1	N/A	N/A	N/A	N/A	N/A	N/A
RI-1-TC-5 1/5		19	N/A	13	13	N/A	N/A	N/A	N/A	N/A	N/A
Spike Recovery I-Stat											
SC-UPPER		.27	N/A	N/A	.10	N/A	N/A	N/A	N/A	N/A	N/A
RI-1-TC-3 1/4		.01	N/A	.02	.02	N/A	N/A	N/A	N/A	N/A	N/A
RI-1-TC-5 1/4		.09	N/A	.07	.06	N/A	N/A	N/A	N/A	N/A	N/A

Table 18. (Continued)

Station	Surrogate Recovery (%)	Toxaphene	Arochlor 1242-1016	Arochlor 1248	Arochlor 1254	Arochlor 1260
Method Blanks						
1	72	50U	50U	50U	50U	50U
2	73	50U	50U	50U	50U	50U
3	88	50U	50U	50U	50U	50U
Duplicates						
SB-UPPER	72	50U	50U	50U	50U	50U
SB-UPPER DUP	79	50U	50U	50U	40J	50U
RI-1-TC-5 2/5	90	50U	50U	50U	50U	50U
RI-1-TC-5 2/5 DUP	77	50U	50U	50U	50U	50U
RI-1-C-39	80	50U	50U	50U	50U	50U
RI-1-C-39 DUP	82	50U	50U	50U	50U	50U
Duplicate RPD						
SB-UPPER		N/A	N/A	N/A	N/A	N/A
RI-1-TC-5 2/5		N/A	N/A	N/A	N/A	N/A
RI-1-C-39		N/A	N/A	N/A	N/A	N/A
Duplicate I-Stat						
SB-UPPER		N/A	N/A	N/A	N/A	N/A
RI-1-TC-5 2/5		N/A	N/A	N/A	N/A	N/A
RI-1-C-39		N/A	N/A	N/A	N/A	N/A
Spike Recovery (%)						
SC-UPPER	73	N/A	N/A	N/A	N/A	N/A
SC-UPPER DUP	87	N/A	N/A	N/A	N/A	N/A
RI-1-TC-3 1/4	89	N/A	N/A	N/A	N/A	N/A
RI-1-TC-3 1/4 DUP	92	N/A	N/A	N/A	N/A	N/A
RI-1-TC-5 1/5	83	N/A	N/A	N/A	N/A	N/A
RI-1-TC-5 1/5 DUP	94	N/A	N/A	N/A	N/A	N/A
Spike Recovery RPD						
SC-UPPER		N/A	N/A	N/A	N/A	N/A
RI-1-TC-3 1/4		N/A	N/A	N/A	N/A	N/A
RI-1-TC-5 1/5		N/A	N/A	N/A	N/A	N/A
Spike Recovery I-Stat						
SC-UPPER		N/A	N/A	N/A	N/A	N/A
RI-1-TC-3 1/4		N/A	N/A	N/A	N/A	N/A
RI-1-TC-5 1/5		N/A	N/A	N/A	N/A	N/A

Table 19. Chlorinated Pesticides and PCBs in Sediments from Richmond Harbor Channel Long Cores (ug/kg dry weight) (U = compound analyzed, but not detected at given detection limit)

Station	Surrogate Recovery (%)	Alpha BHC	Beta BHC	Delta BHC	Gamma BHC	Heptachlor	Aldrin	Heptachlor Epoxide	Endo-sulfan I	Dieldrin	4,4'-DDE	Endrin	Endo-sulfan II
RI-1-W-1	109	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-TC-1 1/4	90	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-TC-1 2/4	80	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-TC-1 3/4	123	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-TC-1 4/4	96	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-TC-2 2/4	83	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-TC-2 3/4	120	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-TC-2 4/4	79	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-TC-3 1/4	97	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-TC-3 2/4	88	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-TC-3 3/4	98	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-TC-3 4/4	92	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-TC-4 1/4	98	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-TC-4 2/4	99	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-TC-4 3/4	101	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-TC-4 4/4	83	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-TC-5 1/5	85	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-TC-5 2/5	90	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-TC-5 3/5	96	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-TC-5 4/5	114	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-TC-5 5/5	98	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U

Table 19. (Continued)

Station	Surrogate Recovery (%)	4,4'-DDD	Endosulfan Sulfate	4,4'-DDT	Methoxy-chlor	Endrin Ketone	Gamma-Chlordane	Alpha-Chlordane	Pentachloro-nitrobenzene	Kelthane	Captan
RI-1-W-1	109	20	5.0U	14	10U	5.0U	5.0U	5.0U	2.5U	12U	25U
RI-1-TC-1 1/4	90	2.5U	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-TC-1 2/4	80	2.5U	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-TC-1 3/4	123	2.5U	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-TC-1 4/4	96	2.5U	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-TC-2 2/4	83	2.5U	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-TC-2 3/4	120	2.5U	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-TC-2 4/4	79	2.5U	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-TC-3 1/4	97	2.5U	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-TC-3 2/4	88	2.5U	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-TC-3 3/4	98	2.5U	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-TC-3 4/4	92	2.5U	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-TC-4 1/4	98	2.5U	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-TC-4 2/4	99	2.5U	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-TC-4 3/4	101	2.5U	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-TC-4 4/4	83	2.5U	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-TC-5 1/5	85	6.7	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-TC-5 2/5	90	2.5U	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-TC-5 3/5	96	2.5U	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-TC-5 4/5	114	2.5U	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-TC-5 5/5	98	2.5U	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U

Table 19. (Continued)

Station	Surrogate Recovery (%)	Toxaphene	Arochlor 1242-1016	Arochlor 1248	Arochlor 1254	Arochlor 1260
RI-1-W-1	109	50U	50U	50U	50U	50U
RI-1-TC-1 1/4	90	50U	50U	50U	50U	50U
RI-1-TC-1 2/4	80	50U	50U	50U	50U	50U
RI-1-TC-1 3/4	123	50U	50U	50U	50U	50U
RI-1-TC-1 4/4	96	50U	50U	50U	50U	50U
RI-1-TC-2 2/4	83	50U	50U	50U	50U	50U
RI-1-TC-2 3/4	120	50U	50U	50U	50U	50U
RI-1-TC-2 4/4	79	50U	50U	50U	50U	50U
RI-1-TC-3 1/4	97	50U	50U	50U	50U	50U
RI-1-TC-3 2/4	88	50U	50U	50U	50U	50U
RI-1-TC-3 3/4	98	50U	50U	50U	50U	50U
RI-1-TC-3 4/4	92	50U	50U	50U	50U	50U
RI-1-TC-4 1/4	98	50U	50U	50U	50U	50U
RI-1-TC-4 2/4	99	50U	50U	50U	50U	50U
RI-1-TC-4 3/4	101	50U	50U	50U	50U	50U
RI-1-TC-4 4/4	83	50U	50U	50U	50U	50U
RI-1-TC-5 1/5	85	50U	50U	50U	50U	50U
RI-1-TC-5 2/5	90	50U	50U	50U	50U	50U
RI-1-TC-5 3/5	96	50U	50U	50U	50U	50U
RI-1-TC-5 4/5	114	50U	50U	50U	50U	50U
RI-1-TC-5 5/5	98	50U	50U	50U	50U	50U

Table 20. Chlorinated Pesticides and PCBs in Sediments from Richmond Harbor Channel Short Cores (ug/kg dry weight) (U = compound analyzed, but not detected at given detection limit, J = Estimated value when result is than less specified detection limit)

Station	Surrogate Recovery (%)	Alpha BHC	Beta BHC	Delta BHC	Gamma BHC	Heptachlor	Aldrin	Heptachlor Epoxide	Endo-sulfan I	Dieldrin	4,4'-DDE	Endrin	Endo-sulfan II
RI-1-C-1	74	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-C-3	77	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-C-5	71	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-C-6	74	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-C-8	72	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-C-10	80	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-C-11	83	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-C-12	84	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-C-14U	78	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-C-14L	74	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-C-16	78	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-C-18	77	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-C-19	76	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-C-20	85	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-C-23	80	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-C-24	74	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-C-25	80	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-C-26	73	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-C-29	85	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-C-30	76	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-C-32	84	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-C-33	80	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-C-35	65	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U
RI-1-C-36	75	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	5.1	2.5U	2.5U
RI-1-C-38	75	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	4.8	10	2.5U	2.5U
RI-1-C-39	80	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	7.5	2.5U	2.5U
RI-1-C-41	80	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	3.0	2.5U	2.5U

Table 20. (Continued)

Station	Surrogate Recovery (%)	4,4'-DDD	Endosulfan Sulfate	4,4'-DDT	Methoxy-chlor	Endrin Ketone	Gamma-Chlordane	Alpha-Chlordane	Pentachloro-nitrobenzene	Kelthane	Captan
RI-1-C-1	74	2.5U	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-C-3	77	2.5U	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-C-5	71	2.5U	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-C-6	74	2.5U	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-C-8	72	3.2	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-C-10	80	2.5U	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-C-11	83	3.6	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-C-12	84	4.6	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-C-14U	78	2.5U	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-C-14L	74	3.8	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-C-16	78	2.5U	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-C-18	77	2.5U	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-C-19	76	3.6	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-C-20	85	3.2	5.0U	2.5J	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-C-23	80	2.5U	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-C-24	74	2.5U	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-C-25	80	3.3	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-C-26	73	13	5.0U	5.9	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-C-29	85	20	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-C-30	76	3.2	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-C-32	84	19	5.0U	31	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-C-33	80	1.9J	5.0U	5.0U	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-C-35	65	6.0	5.0U	6.2	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-C-36	75	29	5.0U	41	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-C-38	75	55	5.0U	41	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-C-39	80	32	5.0U	310	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
RI-1-C-41	80	28	5.0U	22	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U

Table 20. (Continued)

Station	Surrogate Recovery (%)	Toxaphene	Arochlor 1242-1016	Arochlor 1248	Arochlor 1254	Arochlor 1260
RI-1-C-1	74	50U	50U	50U	50U	50U
RI-1-C-3	77	50U	50U	50U	50U	50U
RI-1-C-5	71	50U	50U	50U	50U	50U
RI-1-C-6	74	50U	50U	50U	50U	50U
RI-1-C-8	72	50U	50U	50U	50U	50U
RI-1-C-10	80	50U	50U	50U	50U	50U
RI-1-C-11	83	50U	50U	50U	50U	50U
RI-1-C-12	84	50U	50U	50U	50U	50U
RI-1-C-14U	78	50U	50U	50U	50U	50U
RI-1-C-14L	74	50U	50U	50U	50U	50U
RI-1-C-16	78	50U	50U	50U	50U	50U
RI-1-C-18	77	50U	50U	50U	50U	50U
RI-1-C-19	76	50U	50U	50U	50U	50U
RI-1-C-20	85	50U	50U	50U	50U	50U
RI-1-C-23	80	50U	50U	50U	50U	50U
RI-1-C-24	74	50U	50U	50U	50U	50U
RI-1-C-25	80	50U	50U	50U	50U	50U
RI-1-C-26	73	50U	50U	50U	50U	50U
RI-1-C-29	85	50U	50U	50U	50U	50U
RI-1-C-30	76	50U	50U	50U	50U	50U
RI-1-C-32	84	50U	50U	50U	50U	50U
RI-1-C-33	80	50U	50U	50U	50U	50U
RI-1-C-35	65	50U	50U	50U	50U	50U
RI-1-C-36	75	50U	50U	50U	50U	50U
RI-1-C-38	75	50U	50U	50U	42J	50U
RI-1-C-39	80	50U	50U	50U	50U	50U
RI-1-C-41	80	50U	50U	50U	50U	50U

Table 21. Chlorinated Pesticides and PCBs in Sediments from Santa Fe Channel (ug/kg dry weight) (U = compound analyzed, but not detected at given detection limit)

Station	Surrogate Recovery (%)	Alpha BHC	Beta BHC	Delta BHC	Gamma BHC	Heptachlor	Aldrin	Heptachlor Epoxide	Endo-sulfan I	Dieldrin	4,4'-DDE	Endrin	Endo-sulfan II
SA-UPPER	70	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	5.8	17	2.5U	2.5U
SB-UPPER	72	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	8.0	18	2.5U	2.5U
SC-UPPER	67	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	5.6	15	2.5U	2.5U
SA-LOWER	77	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.8	4.7	2.5U	2.5U
SB-LOWER	85	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	3.6	3.9	2.5U	2.5U
SC-LOWER	117	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	2.5U	4.3	8.1	2.5U	2.5U

Station	Surrogate Recovery (%)	4,4'-DDD	Endosulfan Sulfate	4,4'-DDT	Methoxy-chlor	Endrin Ketone	Gamma-Chlordane	Alpha-Chlordane	Pentachloro-nitrobenzene	Kelthane	Captan
SA-UPPER	70	150	5.0U	210	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
SB-UPPER	72	190	5.0U	130	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
SC-UPPER	67	84	5.0U	470	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
SA-LOWER	77	49	5.0U	54	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
SB-LOWER	85	44	5.0U	8.2	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U
SC-LOWER	117	78	5.0U	91	10U	5.0U	5.0U	5.0U	2.5U	5.0U	25U

Station	Surrogate Recovery (%)	Toxaphene	Arochlor 1242-1016	Arochlor 1248	Arochlor 1254	Arochlor 1260
SA-UPPER	70	50U	50U	50U	50U	50U
SB-UPPER	72	50U	50U	50U	50U	50U
SC-UPPER	67	50U	50U	50U	50U	50U
SA-LOWER	77	50U	50U	50U	50U	50U
SB-LOWER	85	50U	50U	50U	50U	50U
SC-LOWER	117	50U	50U	50U	50U	50U

Table 22. Quality Control for Chlorinated Pesticides and PCBs in Sediments Reanalyzed from Selected Cores (μg/kg dry wgt) (U = compound analyzed but not detected at given detection limits; * = high recovery due to sample matrix interference; ** = no recovery due to sample matrix interference).

Station	Surrogate Recovery (%)	Alpha BHC	Beta BHC	Gamma BHC	Heptachlor	Aldrin	Heptachlor Epoxide	Endo-sulfan I	Dieldrin	4,4'-DDE	Endrin	Endo-sulfan II
Method Blank												
1	70	1U	1U	1U	1U	1U	1U	1U	2U	2U	2U	2U
2	69	1U	1U	1U	1U	1U	1U	1U	2U	2U	2U	2U
Duplicates												
RI-1-C-37-U	57	10U	10U	10U	10U	10U	10U	10U	20U	20U	20U	20U
RI-1-C-37-U Dup	84	1U	1U	1U	1U	1U	1U	1U	2U	7.8U	2U	2U
RI-1-C-42-U	84	1U	1U	1U	1U	1U	1U	1U	2U	6.4U	2U	2U
RI-1-C-42-U Dup	81	1U	1U	1U	1U	1U	1U	1U	2U	5.7U	2U	2U
Duplicate RPD												
RI-1-C-37-U		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RI-1-C-42-U		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Duplicate I-Stat												
RI-1-C-37-U		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RI-1-C-42-U		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spike Recovery (%)												
RI-1-C-42-U	85	110	90	110	90	100	90	90	110	140*	100	90
RI-1-C-42-U Dup	76	110	80	100	90	100	90	90	110	190*	100	90
Spike Recovery RPD		0	11.8	0	0	0	0	0	0	30.3	0	0
Spike Recovery I-Stat		0	0.06	0	0	0	0	0	0	0.15	0	

Table 22. (Continued)

Station	Surrogate Recovery (%)	4,4'-DDD	Endosulfan Sulfate	4,4'-DDT	Methoxy-Chlor	Endrin Ketone	Gamma-Chlordane	Alpha-Chlordane	Pentachloro-nitrobenzene	Kelthane	Captan	
Method Blank												
1	70	2U	4U	2U	4U	3U	1.5U	1.5U	1U	5U	5U	
2	69	2U	4U	2U	4U	3U	1.5U	1.5U	1U	5U	5U	
Duplicates												
RI-1-C-37-U	57	39	40U	21	40U	30U	15U	15U	10U	50U	50U	
RI-1-C-37-U Dup	84	27	4U	31	4U	3U	1.5U	1.5U	1U	5U	5U	
RI-1-C-42-U	84	22	4U	15	4U	3U	1.5U	1.5U	1U	5U	5U	
RI-1-C-42-U Dup	81	19	4U	7	4U	3U	1.5U	1.5U	1U	5U	5U	
Duplicate RPD												
RI-1-C-37-U		36.4	N/A	38.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RI-1-C-42-U		14.6	N/A	72.7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Duplicate I-Stat												
RI-1-C-37-U		0.18	N/A	0.19	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RI-1-C-42-U		0.17	N/A	0.36	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spike Recovery (%)												
RI-1-C-42-U	85	160*	**	250*	100	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RI-1-C-42-U Dup	76	320*	**	150*	90	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spike Recovery RPD		66.7	N/A	50.0	11.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spike Recovery I-Stat		0.33	N/A	0.23	0.53	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 22. (Continued)

Station	Surrogate Recovery (%)	Toxaphene	Arochlor 1242-1016	Arochlor 1248	Arochlor 1254	Arochlor 1260
Method Blank						
1	70	150U	20U	20U	20U	20U
2	69	150U	20U	20U	20U	20U
Duplicates						
RI-1-C-37-U	57	50U	250U	250U	37Q	250U
RI-1-C-37-U Dup	84	150U	20U	20U	14J	20U
RI-1-C-42-U	84	150U	20U	20U	9.6J	20U
RI-1-C-42-U Dup	81	150U	20U	20U	9J	20U
Duplicate RPD						
RI-1-C-37-U		N/A	N/A	N/A	90.2	N/A
RI-1-C-42-U		N/A	N/A	N/A	6.5	N/A
Duplicate I-Stat						
RI-1-C-37-U		N/A	N/A	N/A	0.45	N/A
RI-1-C-42-U		N/A	N/A	N/A	0.03	N/A

Table 23. Chlorinated Pesticides and PCBs in Sediments Reanalyzed from Selected Cores (μg/kg dry wgt) [U = compound analyzed, but not detected at given detection limits; J = estimated value when the result is less than the calculated detection limit; Q = value quanitfied from original dilution (1:2)].

Station	Surrogate Recovery (%)	Alpha BHC	Beta BHC	Gamma BHC	Heptachlor	Aldrin	Heptachlor Epoxide	Endo-sulfan I	Dieldrin	4,4'-DDE	Endrin	Endo-sulfan II
RI-1-C-37-U	57	10U	10U	10U	10U	10U	10U	10U	20U	20U	20U	20U
RI-1-C-38-U	55	10U	10U	10U	10U	10U	10U	10U	20U	20U	20U	20U
RI-1-C-39-U	80	1U	1U	1U	1U	1U	1U	1U	2U	2U	2U	2U
RI-1-C-40-U	55	10U	10U	10U	10U	10U	10U	10U	20U	20U	20U	20U
RI-1-C-41-U	85	1U	1U	1U	1U	1U	1U	1U	2U	2.5U	2U	2U
RI-1-C-42-U	84	1U	1U	1U	1U	1U	1U	1U	2U	6.4U	2U	2U

	Surrogate Recovery (%)	4,4'-DDD	Endosulfan Sulfate	4,4'-DDT	Methoxy-chlor	Endrin Ketone	Gamma-Chlordane	Alpha-Chlordane	Pentachloro-nitrobenzene	Kelthane	Captan
RI-1-C-37-U	57	39	40U	21	40U	30U	15U	15U	10U	50U	50U
RI-1-C-38-U	55	29	40U	57	40U	30U	15U	15U	10U	50U	50U
RI-1-C-39-U	80	13	4U	1.2J	4U	3U	1.5U	1.5U	1U	5U	5U
RI-1-C-40-U	55	59	40U	37	40U	30U	15U	15U	10U	50U	50U
RI-1-C-41-U	85	18	4U	6.4	4U	3U	1.5U	1.5U	10U	5U	5U
RI-1-C-42-U	84	22	4U	15	4U	3U	1.5U	1.5U	1U	5U	5U

	Surrogate Recovery (%)	Toxaphene	Arochlor 1242-1016	Arochlor 1248	Arochlor 1254	Arochlor 1260
RI-1-C-37-U	57	1500U	250U	250U	37Q	250U
RI-1-C-38-U	55	1500U	250U	250U	21Q	250U
RI-1-C-39-U	80	150U	20U	20U	20U	20U
RI-1-C-40-U	55	1500U	250U	250U	39Q	250U
RI-1-C-41-U	85	150U	20U	20U	7.8J	20U
RI-1-C-42-U	84	150U	20U	20U	9.6J	20U

Table 24. Quality Control for Herbicide Acids and Acidic Phenols in Sediments from Richmond Harbor Channel (ug/kg dry weight) (U = compound analyzed, but not detected at given detection limit)

Station	Surrogate Recovery (%)	Silvex	Penta-chloro-phenol	4,6-Dinitro-2-Methyl-phenol	4-Nitro-phenol	2-Nitro-phenol	2,4-Dinitro-phenol	2,4-DB	2,4,5-T	Dinoseb	2,4D
Blanks											
1	76	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
2	63	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
3	123	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
Duplicates											
SB-UPPER	99	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
SB-UPPER DUP	133	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-TC-5 2/5	75	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-TC-5 2/5DUP	41	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-C-39	67	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-C-39 DUP	114	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
Spike Recovery (%)											
SC-UPPER	92	71	97	36	N/A	N/A	27	74	61	41	78
SC-UPPER DUP	62	55	90	44	N/A	N/A	35	50	39	51	48
RI-1-TC-3 1/4	103	95	93	58	N/A	N/A	39	80	78	55	97
RI-1-TC-3 1/4 DUP	88	83	81	47	N/A	N/A	26	79	74	47	93
RI-1-TC-5 1/5	94	83	94	41	N/A	N/A	32	75	68	53	85
RI-1-TC-5 1/5 DUP	91	83	97	72	N/A	N/A	50	75	72	76	88
Spike Recovery RPD											
SC-UPPER		25	7.5	20	N/A	N/A	26	39	44	22	50
RI-1-TC-3 1/4		13	19	21	N/A	N/A	40	1.3	5.3	16	4.2
RI-1-TC-5 1/5		0	3.1	55	N/A	N/A	44	0	5.7	36	3.5
Spike t-Stat											
SC-UPPER		.12	.04	.10	N/A	N/A	.12	.19	.22	.11	.23
RI-1-TC-3 1/4		.08	.09	.10	N/A	N/A	.20	.01	.03	.08	.02
RI-1-TC-5 1/5		0.0	.02	.51	N/A	N/A	.22	0.0	.03	.18	.02

Table 25. Herbicide Acids and Acidic Phenols in Sediments from Richmond Harbor Channel Long Cores (ug/kg dry weight) (U = compound analyzed, but not detected at given detection limit)

Station	Surrogate Recovery (%)	Silvex	Penta-chloro-phenol	4,6-Dinitro-2-Methyl-phenol	4-Nitro-phenol	2-Nitro-phenol	2,4-Dinitro-phenol	2,4-DB	2,4,5,-T	Dinoseb	2,4D
RI-1-W-1	92	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-TC-1 1/4	83	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-TC-1 2/4	35	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-TC-1 3/4	75	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-TC-1 4/4	101	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-TC-2 2/4	109	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-TC-2 3/4	104	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-TC-2 4/4	74	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-TC-3 1/4	131	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-TC-3 2/4	69	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-TC-3 3/4	74	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-TC-3 4/4	75	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-TC-4 1/4	81	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-TC-4 2/4	81	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-TC-4 3/4	96	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-TC-4 4/4	85	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-TC-5 1/5	88	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-TC-5 2/5	75	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-TC-5 3/5	73	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-TC-5 4/5	70	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-TC-5 5/5	94	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U

Table 26. Herbicide Acids and Acidic Phenols in Sediments from Richmond Harbor Channel Short Cores (ug/kg dry weight) (U = compound analyzed, but not detected at given detection limit)

Station	Surrogate Recovery (%)	Silvex	Pentachlorophenol	4,6-Dinitro-2-Methylphenol	4-Nitrophenol	2-Nitrophenol	2,4-Dinitrophenol	2,4-DB	2,4,5,-T	Dinoseb	2,4D
RI-1-C-1	67	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-C-3	63	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-C-5	62	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-C-6	67	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-C-8	88	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-C-10	108	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-C-11	59	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-C-12	90	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-C-14-U	49	25U	25U	25U	25U	25U	25U	100U	41	25U	100U
RI-1-C-14-L	52	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-C-16	74	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-C-18	139	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-C-19	53	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-C-20	93	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-C-23	112	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-C-24	62	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-C-25	76	25U	31	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-C-26	92	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-C-29	58	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-C-30	54	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-C-32	160	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-C-33	64	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-C-35	115	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-C-36	81	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-C-38	56	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-C-39	67	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
RI-1-C-41	48	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U

Table 27. Herbicide Acids and Acidic Phenols in Sediments from Santa Fe Channel (ug/kg dry weight) (U = compound analyzed, but not detected at given detection limit)

Station	Surrogate Recovery (%)	Silvex	Penta-chloro-phenol	4,6-Dinitro-2-Methyl-phenol	4-Nitro-phenol	2-Nitro-phenol	2,4-Dinitro-phenol	2,4-DB	2,4,5,-T	Dinoseb	2,4D
SA-UPPER	87	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
SB-UPPER	99	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
SC-UPPER	91	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
SA-LOWER	120	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
SB-LOWER	108	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U
SC-LOWER	84	25U	25U	25U	25U	25U	25U	100U	25U	25U	100U

TABLE 28. Quality Control for Organophosphorus Pesticides (ug/kg dry weight) in Sediments (ND = Analyte not found)

Measurements	Surrogate Recovery (%)	Mevinphos	Diazinon	Parathion-methyl	Malathion	Azinophos-methyl	Parathion
Detection Limit		211	211	211	211	211	211
Blanks							
Method Blank	152	ND	3.7	ND	ND	ND	0.18
Method Blank	78	ND	ND	ND	ND	ND	ND
Method Blank	94	ND	3.9	ND	ND	ND	0.22
Duplicate							
SA-UPPER	83	ND	ND	ND	ND	ND	ND
SA-UPPER DUP	96	ND	ND	ND	ND	ND	ND
Spike Recovery (%)							
RI-1-TC-3 2/4 SPI	98	11	85	80	74	96	120

TABLE 29. Organophosphorus Pesticides (ug/kg dry weight) in Sediments from Long Cores (ND = Analyte not found)

Station	Surrogate Recovery (%)	Mevinphos	Diazinon	Parathion-methyl	Malathion	Azinphos-methyl	Parathion
Detection Limit		211	211	211	211	211	211
RI-1-W-1	131	ND	ND	ND	ND	ND	ND
RI-1-TC-3 1/4	100	ND	ND	ND	ND	ND	ND
RI-1-TC-3 2/4	106	ND	ND	ND	ND	ND	ND
RI-1-TC-3 3/4	105	ND	ND	ND	ND	ND	ND
RI-1-TC-3 4/4	95	ND	ND	ND	ND	ND	ND
RI-1-TC-5 1/5	105	ND	ND	ND	ND	ND	ND
RI-1-TC-5 2/5	109	ND	ND	ND	ND	ND	ND
RI-1-TC-5 3/5	75	ND	ND	ND	ND	ND	ND
RI-1-TC-5 4/5	31	ND	ND	ND	ND	ND	ND
RI-1-TC-5 5/5	141	ND	ND	ND	ND	ND	ND

TABLE 30. Organophosphorus Pesticides (ug/kg dry weight) in Sediments from Richmond Harbor Channel Short Cores (ND = Analyte not found)

Station	Surrogate Recovery (%)	Mevin-phos	Dia-zinon	Parathion-methyl	Mala-thion	Azinphos-methyl	Para-thion
Detection Limit		211	211	211	211	211	211
RI-1-C-1	94	ND	4.8	ND	ND	ND	ND
RI-1-C-3	75	ND	ND	ND	ND	ND	ND
RI-1-C-5	66	ND	ND	ND	ND	ND	ND
RI-1-C-24	109	ND	ND	ND	ND	ND	ND
RI-1-C-25	80	ND	ND	ND	ND	ND	ND
RI-1-C-26	89	ND	2.7	8.5	ND	ND	ND
RI-1-C-38	89	ND	ND	ND	ND	ND	ND
RI-1-C-39	92	ND	ND	ND	ND	ND	ND
RI-1-C-41	101	ND	ND	ND	ND	ND	ND

TABLE 31. Organophosphorus Pesticides (ug/kg dry weight) in Sediments from Santa Fe Channel (ND = Analyte not found).

Measurements	Surrogate Recovery (%)	Mevinphos	Diazinon	Parathion-methyl	Malathion	Azinophos-methyl	Parathion
Detection Limit		211	211	211	211	211	211
SA-UPPER	83	ND	ND	ND	ND	ND	ND
SB-UPPER	93	ND	ND	ND	ND	ND	ND
SC-UPPER	108	ND	ND	ND	ND	ND	ND
SA-LOWER	106	ND	ND	ND	ND	ND	ND
SB-LOWER	63	ND	ND	ND	ND	ND	ND
SC-LOWER	73	ND	ND	ND	ND	ND	ND

TABLE 32. Quality Control for Dioxins and Furans in Reanalyzed Sediments: Matrix Blank (MB) (ng/kg) and Matrix Spike (MS) (%).

	TCDD		TCDF		PeCDD		PeCDF			HxCDD			
Station	Total	2378-	Total	2378-	Total	12378-	Total	12378-	23478-	Total	123478-	123678-	123789-
Blank													
MB	ND	1.10U	ND	0.41U	ND	0.33U	ND	0.46U	0.51U	ND	0.56U	0.47U	0.36U
Spike Recoveries (%)													
MS	99	99	103	103	108	108	96	95	98	125	95	115	153

	HxCDF					HpCDD		HpCDF			OCDD	OCDF
Station	Total	123478-	123678-	123789-	234678-	Total	1234678-	Total	1234678-	1234789-	Total	Total
Blank												
MB	ND	0.27U	0.36U	0.46U	0.43U	ND	1.00U	ND	0.51U	0.36U	23.00	0.85U
Spike Recoveries (%)												
MS	100	103	100	103	93	90	90	106	108	105	84	101

TABLE 33. Quality Control for Dioxins and Furans in Reanalyzed Sediments: Surrogate Recoveries (%)

Internal Standard	SA Upper	SB Upper	RI-1-C-5	RI-1-C-26	RI-1-C-38	Method	Matrix
2378-TCDD-C13	83	85	59	82	84	61	79
2378-TCDD-C137	73	79	49	67	77	56	70
2378-TCDF-C13	67	77	52	72	77	54	71
12378-PeCDD-C13	71	60	50	67	67	66	40
12378-PeCDF-C13	60	57	50	65	67	54	63
23478-PeCDF-C13	57	53	46	61	63	55	62
123478-HxCDD-C13	60	76	61	68	67	57	84
123678-HxCDD-C13	29	40	35	61	42	68	43
123478-HxCDF-C13	63	93	47	67	86	55	52
123678-HxCDF-C13	57	71	52	71	74	58	60
123789-HxCDF-C13	65	73	48	66	72	54	63
234678-HxCDF-C13	36	47	59	79	54	55	64
1234678-HpCDD-C13	52	75	54	78	61	68	70
1234678-HpCDF-C13	50	78	51	77	66	60	64
1234789-HpCDF-C13	66	103	64	91	87	67	75
OCDD-C13	76	112	67	92	84	65	71

TABLE 34. Dioxins and Furans in Reanalyzed Sediments (ng/kg).

	TCDD		TCDF		PeCDD		PeCDF			HxCDD			
Station	Total	2378-	Total	2378-	Total	12378-	Total	12378-	23478-	Total	123478-	123678-	123789-
SA Upper	1.5	1.1U	24.0	5.6	1.3	1.3	38	1.0U	1.6	190	3.0	11.0	12.0
SB Upper	1.6	1.2U	24.0	3.8	ND	1.1U	31	0.9U	1.5	100	1.3U	7.1	7.9
RI-1-C-5	ND	1.0U	8.7	3.3	ND	0.6U	11	0.5U	0.7U	40	1.2U	4.6	1.0U
RI-1-C-26	2.0	0.9U	34.0	4.5	ND	1.0U	31	0.9	1.8	73	1.4	5.8	2.1
RI-1-C-38	ND	1.2U	28.0	3.7	ND	1.1U	28	1.1U	1.7	100	2.0	6.8	7.7

	HxCDF					HpCDD		HpCDF			OCDD	OCDF
Station	Total	123478-	123678-	123789-	234678-	Total	1234678-	Total	1234678-	1234789-	Total	Total
SA Upper	66	4.5	2.6	3.5	1.1U	970	180	150	43	2.4U	1700	130
SB Upper	44	2.5	2.2	3.2	1.1U	450	110	76	26	1.4U	1000	74
RI-1-C-5	20	1.0U	1.3U	1.1U	1.1U	120	46	34	12	1.4U	360	29
RI-1-C-26	37	2.2U	1.2U	1.5U	1.0U	230	88	48	19	1.1U	690	34
RI-1-C-38	59	4.8	2.3	2.5	0.7U	400	110	67	23	1.9U	880	51

The compound, 2,3,7,8-TCDD was below the detection limit about 1 ng/kg in all samples. The total of all TCDD congeners ranged from below detection to 2 ng/kg. The 2,3,7,8-TCDF concentrations range from 3 to 6 ng/kg, and the total TCDF ranged from 9 to 34 ng/kg. The concentrations of the individual penta- and hexa-congeners are generally similar to those of the tetra-congeners, with only station SA-Upper containing more than 8 ng/kg of two congeners. The hepta- and octa-compounds were generally in the range of 1 to 100 ng/kg.

For completeness, the results of the quality control for original dioxin/furan analyses are presented in Tables 35 and 36, and the results of the original dioxin/furan analyses are presented in Tables 37 and 38.

5.1.4 TOC and Oil and Grease

In both the TOC and the oil and grease data (Table 39) there was good agreement between all duplicates analyzed. Percent recovery was acceptable (101%) for two of the three spikes, and slightly low in the third (75%). In analysis of oil and grease, all blanks were below detection. However, the detection limit based on a 5-g sample was 61 ug/g (dry wt), approximately three times the 20 ug/g required by program. Data for TOC and oil and grease are presented in Tables 40 through 42.

Data comparing different methods of analyzing oil and grease are presented in Table 43. These intra- and interlaboratory comparisons support results presented in Tables 40 through 42.

5.2 Water

5.2.1 Metals

Table 44 presents quality control data for interstitial and elutriate water analyses. For metals, analysis of SRMs resulted in only two metals falling outside of certified range (Cd by 10%, Zn by 5%). The spike recoveries for non-certified metals were in the acceptable range (80 to 120%) for all but Ag. With Ag, 55% of the amount spiked before APDC extraction was recovered; 45% was lost during the APDC preparation. This observation was supported by acceptable recovery (116%) of a spike addition performed when the APDC extract was analyzed to prove that AA detection was accurately measuring

TABLE 35. Quality Control for Original Analyses of Dioxins in Sediments (ug/kg dry weight) (CONC = Concentration; DL = Detection Limit).

	Total TCDD		Total PCDD		Total HCDD		Total HECDD		Total OCDD	
STATION	CONC	DL	CONC	DL	CONC	DL	CONC	DL	CONC	DL
Method Blanks										
1	*	0.0120	*	0.0023	*	0.0006	*	0.0030	0.0034	N/A
2	*	0.0054	*	0.0023	*	0.0009	0.0013	N/A	0.0028	N/A
3	*	0.0058	*	0.0026	*	0.0008	0.0019	N/A	0.0028	N/A
Duplicates										
SA-Upper	*	0.0140	*	0.0420	0.081	0.0007	0.570	0.0039	1.300	0.0045
SA-Upper Dup	*	0.0092	*	0.0110	0.073	0.0007	0.480	0.0039	1.300	0.0045
Duplicate RPD										
SA-Upper	N/A		N/A		10.4		1.7		0	
Duplicate I-Stat										
SA-Upper	N/A		N/A		0.5		0.1		0	
	Total TCDD (%)		Total PCDD (%)		Total HCDD (%)		Total HECDD (%)		Total OCDD (%)	
Spike Recovery										
Native Spike 1	130		110		80		67		116	
Native Spike 2	118		110		64		55		112	
RI-1-TC-3 2/4	112		103		71		65		112	

TABLE 36. Quality Control for Original Analyses of Furans in Sediments (ug/kg dry weight)(CONC = Concentration; DL = Detection Limit).

	Total TCDD		Total PCDD		Total HCDD		Total HECDD		Total OCDD	
STATION	CONC	DL	CONC	DL	CONC	DL	CONC	DL	CONC	DL
Method Blanks										
1	*	0.0039	*	0.0009	*	0.0014	*	0.0011	*	0.0061
2	*	0.0028	*	0.0014	*	0.0007	*	0.0013	*	0.0021
3	*	0.0027	*	0.0014	*	0.0010	*	0.0011	*	0.0045
Duplicates										
SA-Upper	0.170	0.0051	0.054	0.0011	0.070	0.0018	0.098	0.0015	0.100	0.0079
SA-Upper Dup	0.027	0.0051	0.015	0.0011	0.053	0.0018	0.110	0.0015	0.110	0.0079
Duplicate RPD										
SA-Upper	145.2		113.0		27.6		11.5		9.5	
Duplicate I-Stat										
SA-Upper	0.7		0.6		0.1		0.1		0.05	
	Total TCDD (%)		Total PCDD (%)		Total HCDD (%)		Total HECDD (%)		Total OCDD (%)	
Spike Recovery										
Native Spike 1	112		106		116		102		116	
Native Spike 2	108		95		107		96		109	
RI-1-TC-3 2/4	104		100		116		99		110	

TABLE 37. Original Analyses of Dioxins in Sediments (ug/kg dry weight)(CONC = Concentration; DL = Detection Limit).

	Total TCDD		Total PCDD		Total HCDD		Total HECDD		Total OCDD	
STATION	CONC	DL	CONC	DL	CONC	DL	CONC	DL	CONC	DL
SA-Upper	*	0.0140	*	0.0420	0.0810	0.0008	0.5700	0.0039	1.3000	0.0045
SB-Upper	*	0.0110	*	0.0035	0.0270	0.0007	0.1200	0.0035	0.3800	0.0041
SC-Upper	*	0.0050	*	0.0071	0.0440	0.0006	0.1800	0.0034	0.6400	0.0040
SA-Lower	*	0.0039	*	0.0035	0.0240	0.0008	0.1300	0.0012	0.4700	0.0026
SB-Lower (f)	*	0.0063	*	0.0042	0.0100	0.0007	0.0530	0.0016	0.1900	0.0024
SC-Lower	*	0.0033	*	0.0019	0.0140	0.0007	0.0620	0.0016	0.2600	0.0024
RI-1-W-1	*	0.0017	*	0.0008	0.0033	0.0005	0.0150	0.0024	0.0630	0.0028
RI-1-TC-3 1/4	*	0.0066	*	0.0029	*	0.0007	0.0050	0.0028	0.0140	0.0033
RI-1-TC-3 2/4	*	0.0064	*	0.0035	*	0.0012	*	0.0028	*	0.0097
RI-1-TC-3 3/4	*	0.0031	*	0.0009	*	0.0006	0.0012	0.0029	0.0035	0.0034
RI-1-TC-3 4/4	*	0.0027	*	0.0011	*	0.0004	*	0.0006	0.0023	0.0026
RI-1-TC-5 1/5	*	0.0090	*	0.0044	*	0.0038	0.0097	0.0042	0.0970	0.0049
RI-1-TC-5 2/5	*	0.0039	*	0.0022	0.0026	0.0006	0.0089	0.0030	0.0380	0.0035
RI-1-TC-5 3/5	*	0.0130	*	0.0051	*	0.0016	*	0.0058	0.0130	0.0038
RI-1-TC-5 4/5	*	0.0068	*	0.0015	*	0.0011	0.0013	0.0024	0.0017	0.0028
RI-1-TC-5 5/5	*	0.0037	*	0.0011	*	0.0002	0.0015	0.0022	0.0030	0.0026
RI-1-C-1	*	0.0110	*	0.0030	0.0230	0.0010	0.0720	0.0150	0.2500	0.0033
RI-1-C-3	*	0.0055	*	0.0040	0.0052	0.0009	0.0350	0.0019	0.1800	0.0030
RI-1-C-5	0.0038	0.0072	0.0023	0.0030	0.0320	0.0012	0.0810	0.0170	0.3100	0.0037
RI-1-C-24	*	0.0051	*	0.0023	0.0017	0.0009	0.0150	0.0002	0.0730	0.0031
RI-1-C-25	*	0.0059	*	0.0024	0.0140	0.0009	0.0540	0.0020	0.2700	0.0031
RI-1-C-26	0.0110	0.0073	*	0.0067	0.0400	0.0011	0.1400	0.0023	0.5400	0.0035
RI-1-C-38 (f)	*	0.0380	*	0.0077	0.0450	0.0011	0.2100	0.0170	0.8700	0.0036
RI-1-C-39	*	0.0051	*	0.0150	0.0120	0.0007	0.0430	0.0016	0.1700	0.0025
RI-1-C-41	*	0.0039	*	0.0032	0.0180	0.0007	0.0580	0.0016	0.2500	0.0025

TABLE 38. Original Analyses of Furans in Sediments (ug/kg dry weight) (CONC = Concentration; DL = Detection Limit).

	Total TCDD		Total PCDD		Total HCDD		Total HECDD		Total OCDD	
STATION	CONC	DL	CONC	DL	CONC	DL	CONC	DL	CONC	DL
SA-Upper	0.017	0.0051	0.054	0.0011	0.0070	0.0018	0.0980	0.0015	0.1000	0.0079
SB-Upper	0.036	0.0046	0.012	0.0010	0.0190	0.0016	0.0360	0.0013	0.0390	0.0071
SC-Upper	0.007	0.0044	*	0.0030	0.0250	0.0016	0.0470	0.0013	0.0510	0.0069
SA-Lower	0.066	0.0026	0.025	0.0013	0.0300	0.0006	0.0420	0.0012	0.0430	0.0019
SB-Lower (f)	0.030	0.0023	0.011	0.0012	0.0130	0.0008	0.0190	0.0009	0.0210	0.0039
SC-Lower	0.017	0.0023	0.009	0.0012	0.0110	0.0008	0.0200	0.0009	0.0240	0.0038
RI-1-W-1	0.067	0.0031	0.014	0.0007	0.0110	0.0011	0.0097	0.0009	0.0110	0.0049
RI-1-TC-3 1/4	*	0.0023	*	0.0016	*	0.0012	*	0.0016	*	0.0079
RI-1-TC-3 2/4	*	0.0033	*	0.0013	*	0.0013	*	0.0016	*	0.0059
RI-1-TC-3 3/4	*	0.0019	*	0.0007	0.0006	0.0013	*	0.0007	*	0.0031
RI-1-TC-3 4/4	*	0.0025	*	0.0007	*	0.0005	*	0.0011	*	0.0034
RI-1-TC-5 1/5	*	0.0080	*	0.0024	*	0.0037	0.0040	0.0016	0.0075	0.0085
RI-1-TC-5 2/5	*	0.0057	*	0.0018	0.0047	0.0014	0.0110	0.0011	0.0072	0.0061
RI-1-TC-5 3/5	*	0.0067	*	0.0038	*	0.0029	0.0037	0.0012	*	0.0130
RI-1-TC-5 4/5	*	0.0024	*	0.0011	0.0006	0.0011	*	0.0011	*	0.0057
RI-1-TC-5 5/5	*	0.0023	*	0.0016	0.0005	0.0010	*	0.0007	*	0.0026
RI-1-C-1	0.036	0.0032	0.025	0.0016	0.0220	0.0008	0.0210	0.0015	0.0190	0.0025
RI-1-C-3	0.023	0.0028	0.004	0.0015	0.0110	0.0010	0.0140	0.0011	0.0140	0.0047
RI-1-C-5	0.080	0.0036	0.025	0.0018	0.0260	0.0009	0.0240	0.0017	0.0210	0.0028
RI-1-C-38	0.028	0.0035	0.029	0.0018	0.0350	0.0009	0.0850	0.0017	0.1600	0.0027
RI-1-C-24	0.013	0.0029	0.005	0.0015	0.0072	0.0011	0.0073	0.0012	0.0064	0.0050
RI-1-C-25	0.041	0.0029	0.004	0.0015	0.0087	0.0010	0.0180	0.0012	0.0210	0.0049
RI-1-C-26	0.100	0.0033	0.049	0.0017	0.0430	0.0012	0.0470	0.0013	0.0400	0.0056
RI-1-C-39	0.045	0.0023	0.020	0.0012	0.0170	0.0008	0.0210	0.0009	0.0200	0.0039
RI-1-C-41	0.056	0.0023	0.023	0.0012	0.0210	0.0008	0.0230	0.0009	0.0220	0.0039

TABLE 39. Quality Control for Total Organic Carbon and Oil and Grease in Sediments

Station	TOC (%)	Oil and Grease ($\mu g/g$)
Achieved Detection Limit	0.06	61*
Duplicates		
RI-1-C-6	0.79	68
RI-1-C-6	0.80	76
RPD	1.3%	11%
I	0.01	0.1
RI-1-C-19	1.11	84
RI-1-C-19	1.16	81
RPD	4.4%	3.6%
I	0.02	0.2
SA-UPPER	0.82	302
SA-UPPER	0.72	296
RPD	13%	2.0%
I	0.65	0.0
Laboratory Internal Duplicates, TOC		
SA-UPPER	0.82	-
SA-UPPER	0.79	-
RPD	3.7%	NA
I	0.02	NA
RI-1-TC-1 2/4	0.72	-
RI-1-TC-1 2/4	0.72	-
RPD	0%	NA
I	0.00	NA

---

* Achieved Detection limit is based on a 5-g sample. Actual level of detection varies with sample size.
NA = not applicable.
\- = data not available.
RPD = Relative Percent Difference.
I = Industrial Statistic I.

TABLE 39. (Continued)

Station	TOC (%)	Oil and Grease (μg/g)
RI-1-TC-5 5/5	0.57	-
RI-1-TC-5 5/5	0.58	-
RPD	1.7%	NA
I	0.01	NA
RI-1-C-1	0.94	-
RI-1-C-1	0.95	-
RPD	1.1%	NA
I	0.01	NA
RI-1-C-38	0.95	-
RI-1-C-38	0.97	-
RPD	2.1%	NA
I	0.01	NA
RI-1-C-20	0.42	-
RI-1-C-20	0.43	-
RPD	2.4%	NA
I	0.01	NA
SRM MESS-1 STD	2.32	-
SRM MESS-1 STD	2.21	-
RPD	4.9%	NA
I	0.02	NA
Reference Material		
SRM MESS-1 STD-1	2.23	NA
SRM MESS-1 STD-2	2.32	NA
SRM MESS-1 STD-3	2.17	NA

NA = not applicable.
- = data not available.
RPD = Relative Percent Difference.
I = Industrial Statistic I.

TABLE 39. (Continued)

Station	TOC (%)	Oil and Grease (μg/g)
Spikes (Oil and Grease)		
RI-1-C-6	NA	68
RI-1-C-6 + Spike	NA	287
Amount Spiked	NA	284
Percent Recovery	NA	75
RI-1-C-16	NA	< 34
RI-1-C-16 + Spike	NA	219
Amount Spiked	NA	217
Percent Recovery	NA	101
RI-1-TC-3 2/4	NA	< 47
RI-1-TC-3 2/4 + Spike	NA	294
Amount Spiked	NA	291
Percent Recovery	NA	101
Procedural Blank-1	NA	< 61
Procedural Blank-2	NA	< 61
Solvent Blank	NA	< 62

NA = not applicable.

TABLE 40. Total Organic Carbon (TOC) and Oil and Grease in Sediments From Long Cores[a]

Station	TOC (%)	Oil and Grease (μg/g)
Achieved Detection Limit	0.06	61*
RI-1-W-1	0.31	< 40
RI-1-TC-1 1/4	0.77	< 43
RI-1-TC-1 2/4	0.72	< 45
RI-1-TC-1 3/4	0.67	< 44
RI-1-TC-1 4/4	0.16	< 37
RI-1-TC-3 1/4	0.45	< 42
RI-1-TC-3 2/4	0.68	< 47
RI-1-TC-3 3/4	0.66	< 44
RI-1-TC-3 4/4	0.08	< 38
RI-1-TC-5 1/5	0.92	111
RI-1-TC-5 2/5	0.56	187
RI-1-TC-5 3/5	1.07	128
RI-1-TC-5 4/5	0.57	< 47
RI-1-TC-5 5/5	0.13	< 36
RI-1-TC-4 1/4	0.68	< 49
RI-1-TC-4 2/4	0.49	< 42
RI-1-TC-4 3/4	0.10	56
RI-1-TC-4 4/4	0.08	< 37
RI-1-TC-2 1/4	0.62	< 48
RI-1-TC-2 2/4	0.57	< 45
RI-1-TC-2 3/4	0.66	< 46
RI-1-TC-2 4/4	0.74	< 48

(a) Cores were divided into 4 or 5 vertical sections numbered 1 (top of core) through 4 or 5 (bottom of core).

* Achieved detection limit for oil and grease is based on a 5-g sample. Actual level of detection varies with sample size.

TABLE 41. Total Organic Carbon and Oil and Grease in Sediments From Richmond Harbor Channel Short Cores

Station	TOC (%)	Oil and Grease (μg/g)
Achieved Detection Limit	0.06	61*
RI-1-C-1	0.94	57
RI-1-C-3	0.94	64
RI-1-C-5	1.03	89
RI-1-C-6	0.79	68
RI-1-C-8	1.18	93
RI-1-C-10	1.10	124
RI-1-C-11	1.16	100
RI-1-C-12	1.19	67
RI-1-C-14-U	1.23	109
RI-1-C-14-L	1.22	179
RI-1-C-16	0.06	< 34
RI-1-C-18	0.75	99
RI-1-C-19	1.11	84
RI-1-C-20	0.42	51
RI-1-C-23	0.68	< 52
RI-1-C-24	0.71	< 57
RI-1-C-25	0.56	254
RI-1-C-26	0.84	155
RI-1-C-29	0.48	71
RI-1-C-30	0.31	87
RI-1-C-32	1.14	156
RI-1-C-33	0.29	< 40
RI-1-C-35	0.44	< 50
RI-1-C-36	1.06	222
RI-1-C-38	0.95	262
RI-1-C-39	0.28	50
RI-1-C-41	0.28	124

---

* Achieved detection limit for oil and grease is based on a 5-g sample. Actual level of detection varies with sample size.

TABLE 42. Total Organic Carbon and Oil and Grease in Santa Fe Channel Sediment

Station	TOC (%)	Oil and Grease ($\mu g/g$)
Achieved Detection Limit	0.06	61*
SA-UPPER	0.82	302
SB-UPPER	0.72	285
SC-UPPER	0.75	268
SA-LOWER	0.37	88
SB-LOWER	0.29	< 42
SC-LOWER	0.32	83

---

* Achieved detection limit is based on a 5-g (dry wgt) sample. Actual level of detection varies with sample size).

TABLE 43. Concentrations of Oil and Grease in Sediments Analyzed in Three Samples Using Several Techniques (μg/g or ppm dry wt)

	Method				
Sample No.	1	2a	2b	3a	3b
SB-Upper	285	215	148	226	110
RI-1-TC-5 2/5	187	132	211	171	120
RI-1-C-6	76	42	53	15.5	NA

NA = Not analyzed
1 = Single extraction by Battelle, initial testing
2a = Single extraction by Battelle, second testing
2b = Double extraction by Battelle, second testing
3a = Single extraction by Battelle, third testing
3b = Double extraction by commercial laboratory, third testing

Double extraction is considered a more sensitive technique than single extraction.

TABLE 44. Quality Control for Metals in Water

Station	Concentration (µg/L)												
	Ag	As	Be	Cd	Cr	Cu	Hg (ng/L)	Ni	Pb	Sb	Se	Tl	Zn
Achieved Detection Limit	0.001	0.05	0.01	0.001	0.03	0.011	0.08	0.015	0.010	1.03	1.33	0.91	0.49
Spikes													
Sequim Bay PB	-	-	< 0.01	-	-	-	-	-	-	2.38	< 1.33	1.56	-
Sequim Bay PB + Spike	-	-	0.22	-	-	-	-	-	-	17.88	20.74	18.24	-
Amount Spiked	-	-	0.25	-	-	-	-	-	-	13.30	19.61	19.61	-
Percent Recovery	-	-	88	-	-	-	-	-	-	117	106	85	-
SRM CASS-1	0.002	-	-	-	-	-	-	-	-	-	-	-	-
SRM CASS-1 + Spike	0.013	-	-	-	-	-	-	-	-	-	-	-	-
Amount Spiked	0.020	-	-	-	-	-	-	-	-	-	-	-	-
Percent Recovery	55	-	-	-	-	-	-	-	-	-	-	-	-
Standard Reference Materials													
SRM CASS-1	-	1.09	-	0.034	0.127	0.291	-	0.296	0.278	-	-	-	1.14
Certified	-	1.34	-	0.026	0.118	0.291	-	0.290	0.251	-	-	-	0.980
Value	-	±0.07	-	±0.005	±0.021	±0.027	-	±0.031	±0.027	-	-	-	±0.099
SRM NASS-1	-	1.60	-	-	-	-	-	-	-	-	-	-	-
Certified	-	1.65	-	-	-	-	-	-	-	-	-	-	-
Value	-	±0.19	-	-	-	-	-	-	-	-	-	-	-
Duplicate													
SB-UPPER	0.050	4.84	<0.01	0.010	0.33	0.309	0.83	1.035	0.150	< 1.03	< 0.86	1.04	1.30
SB-UPPER	0.009	5.16	<0.01	0.004	0.29	0.356	0.10	0.600	0.115	1.19	< 0.86	< 0.91	1.79

PB = Procedural Blank.
- = Data not available.
NA = not applicable.

Ag. Because of low recovery, samples were rerun twice, and yielded even lower recoveries (50%). The next step was to repeat the APDC process starting with new standard and spike solutions. This was also done twice, and in both cases the data were rejected because reagent blanks prepared along with the APDC extracts were too high. Data for metals in water are found in Tables 45 and 46. The field data for Ag is quite low and would not be of concern were the numbers doubled to account for 50% recoveries.

5.2.2 Organotins

Table 47 presents quality control data for organotins in water, and Tables 48 and 49 present field data.

5.2.3 Organic Compounds

Base/Neutral Semivolatile Compounds

Table 50 presents quality control data for elutriate and interstitial-water analyses. Spike recoveries ranged between 54 and 81% for the four compounds spiked. Detection limits were below the levels expected, except for 3,3'-Dichlorobenzidine and Benzidine which were anticipated to be high. Data for semivolatile compounds in water are presented in Table 51.

Chlorinated Pesticides and PCBs

Quality control data for chlorinated pesticides and PCBs in elutriate and interstitial water are presented in Table 52. Detection limits for various compounds are below or at the expected values. Surrogate recoveries are reasonable, with the exception of the interstitial water sample for Station SA-Upper. Most spike recoveries were reasonable. As anticipated, spike recovery for Dicofol was very high. Values for gamma-HCH, Captan, and DDE are also slightly high. The I-Stat and RPD for the duplicate of DDD are 0.09 and 0.18, respectively. Station data for chlorinated pesticides and PCBs in elutriate and interstitial water are located in Table 53.

Herbicide Acids and Acidic Phenols

Table 54 presents quality control data for elutriate and interstitial water analyses. Spike recoveries, surrogate recoveries, detection limits, I-Stats, and RPDs were reasonable.

TABLE 45. Metals in Interstitial Water

Station	Ag	As	Be	Cd	Cr	Cu	Hg (ng/L)	Ni	Pb	Sb	Se	Tl	Zn
	Concentration (μg/L)												
Achieved Detection Limit	0.001	0.05	0.01	0.001	0.03	0.011	0.08	0.015	0.010	1.03	1.33	0.91	0.49
SA-UPPER	0.006	18.78	< 0.01	0.022	0.54	0.313	1.63	1.391	0.414	1.19	< 1.33	1.04	4.07
SB-UPPER	0.007	13.08	< 0.01	0.025	1.07	0.415	3.85	1.826	0.494	< 1.03	< 1.33	< 0.91	7.16
SC-UPPER	0.003	12.51	< 0.01	0.034	0.51	0.364	1.80	2.400	0.540	< 1.03	< 1.33	2.08	2.28
Sequim Bay	<0.001	-	< 0.01	0.052	< 0.03	0.324	-	0.235	0.012	< 1.03	< 1.33	-	1.63
Sequim Bay PB	<0.001	1.41	< 0.01	0.129	0.35	0.880	4.74	1.130	0.333	2.38	< 1.33	1.50	7.48

PB = Procedural blank.
\- = data not available.

TABLE 46. Metals in Elutriate Water

	Concentration (µg/L)												
Station	Ag	As	Be	Cd	Cr	Cu	Hg (ng/L)	Ni	Pb	Sb	Se	Tl	Zn
Achieved Detection Limit	0.001	0.05	0.01	0.001	0.03	0.011	0.08	0.015	0.010	1.03	0.86	0.91	0.49
SA-UPPER	0.010	9.13	<0.01	0.010	0.45	0.462	0.56	1.383	0.431	< 1.03	< 0.86	1.04	1.63
SB-UPPER	0.060	4.84	<0.01	0.010	0.33	0.309	0.83	1.035	0.150	< 1.03	< 0.86	1.04	1.30
SB-UPPER	0.009	5.16	<0.01	0.004	0.29	0.356	0.10	0.600	0.115	1.19	< 0.86	< 0.91	1.79
SC-UPPER	0.008	3.77	<0.01	0.057	0.27	0.265	0.66	0.809	0.172	< 1.03	< 0.86	1.04	1.95
Santa Fe Channel PB	0.004	1.32	<0.01	0.077	0.44	5.149	0.74	1.255	0.230	< 1.03	< 0.86	1.56	1.63
Sequim Bay PB	<0.001	2.13	<0.01	0.107	0.36	0.382	0.84	0.774	0.310	< 1.03	< 0.86	1.56	3.09
Sequim Bay	<0.001	-	<0.01	0.052	< 0.03	0.324	-	0.235	0.012	< 1.03	< 1.33	-	1.63

PB = Procedural blank.
- = Data not available.

TABLE 47. Quality Control for Organotins in Water

Station	Propyl Tin % Recovery	Butyltin Concentration (ng/L) Tri	Di	Mono	Total
Achieved Detection Limit		3.1	3.5	2.5	NA
SB-UPPER	47	< 2.1	3.7	3.4	7.1
SB-UPPER	42	< 3.1	< 3.5	< 2.5	NA
Sequim Bay	63	12	< 2.8	4.4	16.4
Sequim Bay + Spike	74	188	160	50	NA
Amount Spiked		200	200	200	NA
% Recovery		88	80	23	NA

---

* Achieved detection limit is based on a 500 mL sample. Actual level of detection varies with sample size.

NA = not applicable.

TABLE 48. Organotins in Interstitial Water from Santa Fe Channel

Station	Propyl Tin % Recovery	Butyltin Concentration (ng/L) Tri	Di	Mono	Total
Achieved* Detection Limit		3.1	3.5	2.5	NA
SA-UPPER	59	< 2.7	24	< 2.2	24
SB-UPPER	57	< 3.7	21	11	32
SC-UPPER	60	< 2.7	13	6.8	19.8
Sequim Bay PB	51	< 3.0	86	12	98

---

* Achieved detection limit is based on a 500 mL sample. Actual level of detection varies with sample size.

PB = procedural blank.

NA = not applicable.

TABLE 49. Organotins in Elutriate Water from Santa Fe Channel

Station	Propyl Tin % Recovery	Butyltin Concentration (ng/L) Tri	Di	Mono	Total
Achieved Detection Limit*		3.1	3.5	2.5	NA
SA-UPPER	44	< 3.1	10	7.7	17.7
SB-UPPER	47	< 2.1	3.7	3.4	7.1
SC-UPPER	44	< 2.8	6.8	3.5	10.3
Santa Fe Channel PB	60	< 3.3	13	< 2.7	13
Sequim Bay PB	58	< 2.2	8.6	< 1.8	8.6

* Achieved detection limit is based on a 500 mL sample. Actual level of detection varies with sample size.

PB = procedural blank.

NA = not applicable.

TABLE 50. Quality Control for Semivolatile Compounds in Water (Conc = Concentration in ug/L, DL = Detection Limit, ND = Not Detectable, N/A = Not applicable, Blank = Reagent Water)

Station	Bis(2-chloro-ethyl)ether		1,3-Dichloro-benzene		1,4-Dichloro-benzene		1,2-Dichloro-benzene		Isopropyl) ether		di-n-progylamine		chloro-ethane		Nitro-benzene	
	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL
Blank	ND	20.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	20.0
Duplicate																
SB-UPPER	ND	20.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	20.0
SB-UPPER DUP	ND	20.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	20.0
Spike % Recovery																
Lab Spike	N/A		N/A		54%		N/A		N/A		80%		N/A		N/A	
Procedural Blanks																
QC-EL-SFC	ND	20.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	20.0
QC-EL-SB	ND	20.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	20.0
QC-IW-SB	ND	22.5	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	22.5

Station	Isophorone		Bis(2-chloro-ethoxy)-methane		Naphthalene		Hexachloro-butadiene		Hexachloro-cyclo-pentadiene		2-chloro-naphthalene		Dimethyl-phthalate		Acenaphthylene	
	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL
Blank	ND	5.0	ND	20.0	ND	5.0	ND	5.0	ND	20.0	ND	5.0	ND	5.0	ND	5.0
Duplicate																
SB-UPPER	ND	5.0	ND	20.0	ND	5.0	ND	5.0	ND	20.0	ND	5.0	ND	5.0	ND	5.0
SB-UPPER DUP	ND	5.0	ND	20.0	ND	5.0	ND	5.0	ND	20.0	ND	5.0	ND	5.0	ND	5.0
Spike % Recovery																
Lab Spike	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A	
Procedural Blanks																
QC-EL-SFC	ND	5.0	ND	20.0	ND	5.0	ND	5.0	ND	20.0	ND	5.0	ND	5.0	ND	5.0
QC-EL-SB	ND	5.0	ND	20.0	ND	5.0	ND	5.0	ND	20.0	ND	5.0	ND	5.0	ND	5.0
QC-IW-SB	ND	5.6	ND	22.5	ND	5.6	ND	5.6	ND	22.5	ND	5.6	ND	5.6	ND	5.6

TABLE 50. (Continued)

Station	2,6-Dinitro-toluene		Acenaphthene		2,4-Dinitro-toluene		Diethyl-phthalate		4-Chloro-phenyl-phenylether		Fluorene		N-Nitroso-diphenyl-amine		4-Bromophenyl-phenylether	
	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL
Blank	ND	20.0	ND	5.0	ND	20.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0
Duplicate																
SB-UPPER	ND	20.0	ND	5.0	ND	20.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0
SB-UPPER DUP	ND	20.0	ND	5.0	ND	20.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0
Spike % Recovery																
Lab Spike	N/A		66%		81%		N/A		N/A		N/A		N/A		N/A	
Procedural Blanks																
QC-EL-SFC	ND	20.0	ND	5.0	ND	20.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0
QC-EL-SB	ND	20.0	ND	5.0	ND	20.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0
CC-IW-SB	ND	22.5	ND	5.6	ND	22.5	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	5.6

Station	Hexachloro-benzene		Phenanthrene		Anthracene		Di-n-butyl-phthalate		Fluoranthene		Pyrene		Butyl-benzyl-phthalate		3,3'-Dichloro-benzidine	
	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL
Blank	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	50.0
Duplicate																
SB-UPPER	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	50.0
SB-UPPER DUP	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	50.0
Spike % Recovery																
Lab Spike	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A	
Procedural Blanks																
QC-EL-SFC	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	50.0
QC-EL-SB	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	50.0
QC-IW-SB	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	56.2

TABLE 50. (Continued)

Station	Benzo(a)-anthracene		Chrysene		Bis(2-ethyl-hexyl)-phthalate		Di-n-octyl-phthalate		Benzo(b)-fluoranthene		Benzo(k)-fluoranthene		Benzo(a)-pyrene		Indeno-(1,2,3-CD)-pyrene	
	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL
Blank	ND	5.0	ND	5.0	140.0	5.0	7.4	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0
Duplicate																
SB-UPPER	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0
SB-UPPER DUP	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0
Spike % Recovery																
Lab Spike	N/A		N/A		N/A		N/A		N/A		N/A		N/A		N/A	
Procedural Blanks																
QC-EL-SFC	ND	5.0	ND	5.0	200.0	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0
QC-EL-SB	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0
QC-IW-SB	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	5.6

Station	Dibenzo(A,H)-anthracene		Benzo(G,H,I)-perylene		1,2-Diphenyl-hydrazine		Benzidine	
	Conc	DL	Conc	DL	Conc	DL	Conc	DL
Blank	ND	5.0	ND	5.0	ND	5.0	ND	100.0
Duplicate								
SB-UPPER	ND	5.0	ND	5.0	ND	5.0	ND	100.0
SB-UPPER DUP	ND	5.0	ND	5.0	ND	5.0	ND	100.0
Spike % Recovery								
Lab Spike	N/A		N/A		N/A		N/A	
Procedural Blanks								
QC-EL-SFC	ND	5.0	ND	5.0	ND	5.0	ND	100.0
QC-EL-SB	ND	5.0	ND	5.0	ND	5.0	ND	100.0
QC-IW-SB	ND	5.6	ND	5.6	ND	5.6	ND	112.4

TABLE 51. Semivolatile Compounds in Water (Conc = Concentration in ug/L, DL = Detection Limit, ND = Not detectable)

Station	Bis(2-chloro-ethyl)ether		1,3-Dichloro-benzene		1,4-Dichloro-benzene		1,2-Dichloro-benzene		Bis(2-chloro-isopropyl) ether		N-nitroso-di-n-progylamine		Hexa-chloro-ethane		Nitro-benzene	
	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL
							Elutriate Water									
SA-UPPER	ND	20.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	20.0
SB-UPPER	ND	20.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	20.0
SC-UPPER	ND	20.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	20.0
							Interstitial Water									
SA-UPPER	ND	22.5	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	22.5
SB-UPPER	ND	22.5	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	22.5
SC-UPPER	ND	22.0	ND	5.5	ND	5.5	ND	5.5	ND	5.5	ND	5.5	ND	5.5	ND	22.0

Station	Isophorone		Bis(2-chloro-ethoxy)-methane		Naphthalene		Hexachloro-butadiene		Hexachloro-cyclo-pentadiene		2-chloro-naphthalene		Dimethyl-phthalate		Acenaphthylene	
	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL
							Elutriate Water									
SA-UPPER	ND	5.0	ND	20.0	ND	5.0	ND	5.0	ND	20.0	ND	5.0	ND	5.0	ND	5.0
SB-UPPER	ND	5.0	ND	20.0	ND	5.0	ND	5.0	ND	20.0	ND	5.0	ND	5.0	ND	5.0
SC-UPPER	ND	5.0	ND	20.0	ND	5.0	ND	5.0	ND	20.0	ND	5.0	ND	5.0	ND	5.0
							Interstitial Water									
SA-UPPER	ND	5.6	ND	22.5	ND	5.6	ND	5.6	ND	22.5	ND	5.6	ND	5.6	ND	5.6
SB-UPPER	ND	5.6	ND	22.5	ND	5.6	ND	5.6	ND	22.5	ND	5.6	ND	5.6	ND	5.6
SC-UPPER	ND	5.5	ND	22.0	ND	5.5	ND	5.5	ND	22.0	ND	5.5	ND	5.5	ND	5.5

TABLE 51. (Continued)

Station	2,6-Dinitrotoluene Conc	2,6-Dinitrotoluene DL	Acenaphthene Conc	Acenaphthene DL	2,4-Dinitrotoluene Conc	2,4-Dinitrotoluene DL	Diethylphthalate Conc	Diethylphthalate DL	4-Chlorophenylphenylether Conc	4-Chlorophenylphenylether DL	Fluorene Conc	Fluorene DL	N-Nitrosodiphenylamine Conc	N-Nitrosodiphenylamine DL	4-Bromophenylphenylether Conc	4-Bromophenylphenylether DL
Elutriate Water																
SA-UPPER	ND	20.0	ND	5.0	ND	20.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0
SB-UPPER	ND	20.0	ND	5.0	ND	20.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0
SC-UPPER	ND	20.0	ND	5.0	ND	20.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0
Interstitial Water																
SA-UPPER	ND	22.5	ND	5.6	ND	22.5	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	5.6
SB-UPPER	ND	22.5	ND	5.6	ND	22.5	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	5.6
SC-UPPER	ND	22.0	ND	5.5	ND	22.0	ND	5.5	ND	5.5	ND	5.5	ND	5.5	ND	5.5

Station	Hexachlorobenzene Conc	Hexachlorobenzene DL	Phenanthrene Conc	Phenanthrene DL	Anthracene Conc	Anthracene DL	Di-n-butylphthalate Conc	Di-n-butylphthalate DL	Fluoranthene Conc	Fluoranthene DL	Pyrene Conc	Pyrene DL	Butylbenzylphthalate Conc	Butylbenzylphthalate DL	3,3′-Dichlorobenzidine Conc	3,3′-Dichlorobenzidine DL
Elutriate Water																
SA-UPPER	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	50.0
SB-UPPER	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	50.0
SC-UPPER	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	50.0
Interstitial Water																
SA-UPPER	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	56.2
SB-UPPER	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	56.2
SC-UPPER	ND	5.5	ND	5.5	ND	5.5	ND	5.5	ND	5.5	ND	5.5	ND	5.5	ND	54.9

TABLE 51. (Continued)

Station	Benzo(a)-anthracene		Chrysene		Bis(2-ethyl-hexyl)-phthalate		Di-n-octyl-phthalate		Benzo(b)-fluoranthene		Benzo(k)-fluoranthene		Benzo(a)-pyrene		Indeno-(1,2,3-CD)-pyrene	
	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL
Elutriate Water																
SA-UPPER	ND	5.0	ND	5.0	58.0	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0
SB-UPPER	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0
SC-UPPER	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0	ND	5.0
Interstitial Water																
SA-UPPER	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	5.6
SB-UPPER	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	5.6	ND	5.6
SC-UPPER	ND	5.5	ND	5.5	ND	5.5	ND	5.5	ND	5.5	ND	5.5	ND	5.5	ND	5.5

Station	Dibenzo(A,H)-anthracene		Benzo(G,H,I)-perylene		1,2-Diphenyl-hydrazine		Benzidine	
	Conc	DL	Conc	DL	Conc	DL	Conc	DL
Elutriate Water								
SA-UPPER	ND	5.0	ND	5.0	ND	5.0	ND	100.0
SB-UPPER	ND	5.0	ND	5.0	ND	5.0	ND	100.0
SC-UPPER	ND	5.0	ND	5.0	ND	5.0	ND	100.0
Interstitial Water								
SA-UPPER	ND	5.6	ND	5.6	ND	5.6	ND	112.4
SB-UPPER	ND	5.6	ND	5.6	ND	5.6	ND	112.4
SC-UPPER	ND	5.5	ND	5.5	ND	5.5	ND	109.9

TABLE 52. Quality Control for Chlorinated Pesticides and PCBs in Water (ug/L) (ND = Not detected; a,b,c = Due to coelution on primary column, quantification from secondary column analysis).

Station	Surrogate Percent Recovery	Alpha HCH	Pentachloro-nitro-benzene	Gamma HCH	Beta HCH	Hepta-Chlor	Aldrin	Dicofol	Gamma Chlor-dane	Endo-sulfan I^a	Alpha Chlordane^a
Detection Limit		0.0063	0.0063	0.0063	0.019	0.0063	0.0063	0.013	0.013	0.0063	0.063
Blank	39	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Duplicate											
SB-UPPER	76	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SB-UPPER DUP	75	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Procedural Blank											
QC-EL-SFC	88	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
QC-EL-SB	25	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
QC-IW-SB	73	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Spike Recovery (%)	78	94	91	265	98	90	78	2530	96	108	110

Station	Surrogate Percent Recovery	DDE	DDT	DDD	Dieldrin^b	Captan^b	Endo-Sulfan II	Endrin^c	Dinocap^c
Detection Limits		0.0063	0.013	0.0063	0.0063	0.063	0.0063	0.0063	0.063
Blank	39	ND	ND	ND	ND	ND	ND	ND	ND
Duplicate									
SB-UPPER	76	ND	ND	0.049	ND	ND	0.049	ND	ND
SB-UPPER DUP	75	ND	ND	0.040	ND	ND	0.040	ND	ND
Procedural Blanks									
QC-EL-SFC	88	ND	ND	ND	ND	ND	ND	ND	ND
QC-EL-SB	25	ND	ND	ND	ND	ND	ND	ND	ND
QC-IW-SB	73	ND	ND	ND	ND	ND	ND	ND	ND
Spike Recovery (%)	78	195	105	103	195	212	105	118	157

TABLE 52. (Continued)

Station	Surrogate Percent Recovery	Endo-sulfan Sulfate	Methoxy-chlor	Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260	Toxaphene
Detection Limit		0.013	0.025	0.78	0.78	0.78	0.78	ND
Blank	39	ND	ND	ND	ND	ND	ND	ND
Duplicate								
SB-UPPER	76	0.11	ND	ND	ND	ND	ND	ND
SB-UPPER DUP	75	ND	0.19	ND	ND	ND	ND	ND
Procedural Blanks								
QC-EL-SFC	88	ND	ND	ND	ND	ND	ND	ND
QC-EL-SB	25	ND	ND	ND	ND	ND	ND	ND
QC-IW-SB	73	ND	ND	ND	ND	ND	ND	ND
Spike Recovery (%)	78	127	111	ND	ND	ND	ND	ND

TABLE 53. Chlorinated Pesticides and PCBs in Water (ug/L) (ND = Not detected; a,b,c = Due to coelution on primary column, quantification from secondary column analysis).

Station	Surrogate Percent Recovery	Alpha HCH	Pentachloro-nitro-benzene	Gamma HCH	Beta HCH	Hepta-Chlor	Aldrin	Dicofol	Gamma Chlor-dane	Endo-sulfan I[a]	Alpha Chlordane[a]
Detection Limit		0.0063	0.0063	0.0063	0.019	0.0063	0.0063	0.013	0.013	0.0063	0.063
Elutriate Water											
SA-UPPER	77	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SB-UPPER	76	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SC-UPPER	80	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Interstitial Water											
SA-UPPER	0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SB-UPPER	65	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SC-UPPER	69	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Station	Surrogate Percent Recovery	DDE	DDT	DDD	Dieldrin[b]	Captan[b]	Endo-Sulfan II	Endrin[c]	Dinocap[c]
Detection Limit		0.0063	0.013	0.0063	0.0063	0.063	0.0063	0.0063	0.063
Elutriate Water									
SA-UPPER	77	ND	ND	0.041	ND	ND	ND	ND	ND
SB-UPPER	76	ND	ND	0.049	ND	ND	ND	ND	ND
SC-UPPER	80	ND	ND	0.022	ND	ND	ND	ND	ND
Interstitial Water									
SA-UPPER	0	ND	ND	0.049	ND	ND	ND	ND	ND
SB-UPPER	65	ND	ND	0.027	ND	ND	ND	ND	ND
SC-UPPER	69	ND	ND	0.071	ND	ND	ND	ND	ND

TABLE 53. (Continued)

Station	Surrogate Percent Recovery	Endo-sulfan Sulfate	Methoxy-chlor	Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260	Toxaphene
Detection Limit		0.013	0.025	0.78	0.78	0.78	0.78	ND
				Elutriate Water				
SA-UPPER	77	ND	ND	ND	ND	ND	ND	ND
SB-UPPER	76	0.11	ND	ND	ND	ND	ND	ND
SC-UPPER	80	ND	ND	ND	ND	ND	ND	ND
				Interstitial Water				
SA-UPPER	0	ND	ND	ND	ND	ND	ND	ND
SB-UPPER	65	ND	ND	ND	ND	ND	ND	ND
SC-UPPER	69	ND	ND	ND	ND	ND	ND	ND

TABLE 54. Quality Control for Herbicide Acids and Acidic Phenols (ug/L) in Elutriate and Interstitial Water (ND=Not detected, NA = Not applicable, I-Stat and RPD defined in text).

Station	Surrogate Recovery (%)	2-Nitro-Phenol	MCPA	4-Nitro-Phenol	2,4-D	2-ME-4,6-DNP	PCP	Silvex	2,4-DNP	2,4,5-T	2,4-DB	Dinoseb
Detection Limit		0.50	60	10	2.0	0.50	0.50	0.50	0.50	0.50	2.0	0.50
Blank	77	ND	ND	ND	ND	ND	0.003	0.009	ND	ND	ND	ND
Duplicate												
SB-UPPER	83	0.15	20	0.49	0.070	0.038	ND	0.007	0.059	0.042	0.37	ND
SB-UPPER DUP	85	0.14	24	ND	0.070	0.041	ND	ND	0.051	0.043	0.46	0.051
I-Stat		0.03	0.09	NA	0	0.04	NA	NA	0.07	0.01	0.11	NA
RPD		0.07	0.18	NA	0	0.08	NA	NA	0.15	0.02	0.22	NA
Procedural Blanks												
QC-EL-SFC	89	0.056	3.4	ND	ND	0.012	0.005	0.018	ND	0.051	0.12	0.018
QC-EL-SB	96	0.082	ND	0.61	0.061	0.010	0.009	0.017	ND	0.041	ND	0.014
QC-IW-SB	90	ND	3.5	ND	ND	0.014	0.012	0.030	ND	0.060	ND	0.032
Spike Recovery (%)												
Reagent Water	80	99	160	62	102	69	104	104	53	104	103	69

Station data for herbicide acids and acidic phenols in water are found in Table 55.

Organophosphorus Pesticides

Quality control data for organophosphorus pesticides in water are shown in Table 56. Surrogate recoveries are reasonable except for one procedural blanks in which part of the sample was lost. Spike recoveries ranged between 76 and 112 percent. Detection limits were below those expected. Table 57 presents the data for the organophosphorus interstitial and elutriate water samples.

Dioxins and Furans

Table 58 presents the quality control data for dioxins and furans in water. Detection limits vary considerably, with many of them below the expected amount. Unfortunately, there was not sufficient sample material to repeat the analyses and improve the detection limits. Station data are found in Table 59.

TABLE 55. Herbicide Acids and Acidic Phenols (ug/L) in Elutriate and Interstitial Water (ND = Not detected).

Station	Surrogate Percent Recovery	2-Nitro-Phenol	MCPA	4-Nitro-Phenol	2,4-D	2-ME-4,6-DNP	PCP	Silvex	2,4-DNP	2,4,5-T	2,4-DB	Dinoseb
Detection Limit		0.50	60	10	2.0	0.50	0.50	0.50	0.50	0.50	2.0	0.50
						Elutriate Water						
SA-UPPER	69	0.10	8.6	0.36	0.11	0.029	0.007	0.015	0.026	0.062	0.33	ND
SB-UPPER	83	0.15	20	0.49	0.070	0.038	ND	0.007	0.059	0.042	0.37	ND
SC-UPPER	142	ND	ND	ND	0.51	ND	ND	ND	0.059	0.061	0.80	0.057
						Interstitial Water						
SA-UPPER	73	ND	8.3	ND	0.14	0.014	0.047	0.066	0.016	0.11	0.36	0.030
SB-UPPER	91	ND	22	2.1	0.23	ND	0.012	0.017	ND	0.072	0.33	0.024
SC-UPPER	98	0.28	49	1.5	0.23	0.088	0.021	ND	0.10	0.13	ND	0.11

TABLE 56. Quality Control for Organophosphorus Pesticides (ug/L) in Water (ND = Not detectable; a = A portion of sample was lost during preparation, thereby affecting the recovery)

Station	Surrogate Recovery (%)	Mevin-phos	Dia-zinon	Parathion-methyl	Mala-thion	Azinphos-methyl	Para-thion
Detection Limit		4.0	4.0	4.0	4.0	4.0	4.0
Blank	71	ND	ND	ND	ND	ND	ND
Duplicate							
SB-UPPER	132	ND	ND	ND	ND	ND	ND
SB-UPPER DUP	140	ND	ND	ND	ND	ND	ND
Spike Recovery (%)	79	76	96	99	104	102	112
Procedural Blanks							
QC-EL-SFC	125	Nd	ND	ND	ND	ND	ND
QC-EL-SB	39[a]	ND	ND	ND	ND	ND	ND
QC-IW-SB	113	ND	ND	ND	ND	ND	ND

TABLE 57. Organophosphorus Pesticides (ug/L) in Elutriate and Interstitial Water (ND = Not detected)

Station	Surrogate Recovery (%)	Mevinphos	Diazinon	Parathion-methyl	Malathion	Azinphos-methyl	Parathion
Detection Limit		4.0	4.0	4.0	4.0	4.0	4.0
			Elutriate Water				
SA-UPPER	123	ND	ND	ND	ND	ND	ND
SB-UPPER	132	ND	ND	ND	ND	ND	ND
SC-UPPER	111	ND	ND	ND	ND	ND	ND
			Interstitial Water				
SA-UPPER	102	ND	ND	ND	ND	ND	ND
SB-UPPER	124	ND	ND	ND	ND	ND	ND
SC-UPPER	122	ND	ND	ND	ND	ND	ND

TABLE 58. Quality Control for Dioxins (-CDD) and Furans (-CDF) (ug/L) in Elutriate and Interstitial Water (Conc = Concentration, DL = Detection Limit, ND = Not detected)

STATION	Total Tetra -CDD (a)		Total Penta -CDD		Total Hexa -CDD		Total Hepta -CDD		Octa -CDD	
	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL
Blank	ND	0.000660	ND	0.000170	ND	0.000032	ND	0.000170	0.000110	N/A
Duplicate										
SB-UPPER	ND	0.000130	ND	0.000120	ND	0.000028	ND	0.000077	ND	0.000095
SB-UPPER DUP	ND	0.000110	ND	0.000087	ND	0.000022	0.000053	0.000170	0.000060	N/A
Procedural Blanks										
QC-EL-SFC	ND	0.000110	ND	0.000053	ND	0.000011	0.000045	0.000170	0.000054	N/A
QC-EL-SB	ND	0.000290	ND	0.000270	ND	0.000076	ND	0.000170	ND	0.000340
QC-IW-SB	ND	0.000110	ND	0.000130	ND	0.000028	ND	0.000078	ND	0.000097

Station	Total Tetra -CDF (a)		Total Penta -CDF		Total Hexa -CDF		Total Hepta -CDF		Octa -CDF	
	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL
Blank	ND	0.000130	ND	0.000074	ND	0.000038	ND	0.000064	ND	0.000130
Duplicate										
SB-UPPER	ND	0.000084	ND	0.000040	ND	0.000033	ND	0.000051	ND	0.000110
SB-UPPER DUP	ND	0.000096	ND	0.000043	ND	0.000027	ND	0.000027	ND	0.000130
Procedural Blanks										
QC-EL-SFC	ND	0.000038	ND	0.000024	ND	0.000015	ND	0.000019	ND	0.000073
QC-EL-SB	ND	0.000220	ND	0.000110	ND	0.000063	ND	0.000075	ND	0.000330
QC-IW-SB	ND	0.000094	ND	0.000051	ND	0.000026	ND	0.000022	ND	0.000110

TABLE 59. Dioxins (-CDD) and Furans (-CDF) (ug/L) in Elutriate and Interstitial Water (Conc = Concentration, DL = Detection Limit, ND = Not detected)

STATION	Total Tetra -CDD (a)		Total Penta -CDD		Total Hexa -CDD		Total Hepta -CDD		Octa -CDD	
	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL
					Elutriate Water					
SA-UPPER	ND	0.000080	ND	0.000050	ND	0.000017	0.000052	0.000170	0.000040	N/A
SB-UPPER	ND	0.000130	ND	0.000120	ND	0.000028	ND	0.000077	ND	0.000095
SC-UPPER	0.000059	0.000660	ND	0.000043	ND	0.000019	0.000045	0.000170	0.000053	N/A
					Interstitial Water					
SA-UPPER	ND	0.000160	ND	0.000048	ND	0.000021	0.000048	0.000170	0.000070	N/A
SB-UPPER	ND	0.000130	ND	0.000073	ND	0.000020	ND	0.000060	ND	0.000093
SC-UPPER	ND	0.000095	ND	0.000061	ND	0.000021	0.000070	0.000170	0.000071	N/A

Station	Total Tetra -CDF (a)		Total Penta -CDF		Total Hexa -CDF		Total Hepta -CDF		Octa -CDF	
	Conc	DL	Conc	DL	Conc	DL	Conc	DL	Conc	DL
					Elutriate Water					
SA-UPPER	ND	0.000031	ND	0.000032	ND	0.000020	ND	0.000014	ND	0.000060
SB-UPPER	ND	0.000084	ND	0.000040	ND	0.000033	ND	0.000051	ND	0.000110
SC-UPPER	ND	0.000033	ND	0.000024	ND	0.000022	ND	0.000022	ND	0.000069
					Interstitial Water					
SA-UPPER	ND	0.000059	ND	0.000024	ND	0.000016	ND	0.000028	ND	0.000049
SB-UPPER	ND	0.000082	ND	0.000036	ND	0.000029	ND	0.000035	ND	0.000100
SC-UPPER	ND	0.000055	ND	0.000058	ND	0.000012	ND	0.000020	ND	0.000083

6.0 QUALITY ASSURANCE

Several steps have been taken along the way to ensure that proper quality assurance of the program has been conducted. The Battelle Quality Assurance Engineer, Mr. Rob Cuello, audited the work plan before it was sent to the USACE for approval. In addition, Mr. Cuello was on-site at MSL to audit the handling of the cores from the time they arrived in the laboratory to the time they were ready for chemical analysis. Mr. Cuello met with the QA personnel at the Battelle facility in Columbus, Ohio, to ensure that appropriate QA measures were to be conducted. While in Columbus, Mr. Cuello met with the organic chemists at the point that they were extracting the sediments in order to conduct an audit and to review the protocols. Mr. Cuello audited the data on metals, organotins, TOC, and oil and grease when it was completed. Quality Assurance personnel located in Columbus audited the data on organic compounds. Finally, Mr. Cuello reviewed the report and audited the data tables in the report.

7.0 PROJECT PERSONNEL

Numerous people were involved in conducting Task 4. For the USACE, Ms. Ruth Brodie served as Project Manager, Ms. Sandy Lemlich served as contract manager and provided principal technical oversight, and Dr. Richard Lee provided technical support. Dr. Betsy Brown served as Program Manager for the MSL. Figure 10 presents the organization chart for the MSL participants. Personnel who comprised the field sampling team are presented in Table 60.

TABLE 60. Field Sampling Team

Participant	Responsibility
U.S. Army Corps of Engineers	
Sandy Lemlich	Contract Manager
Edgar Poe	Scientist
Brian Walls	Scientist
Battelle	
Betsy Brown	Program Manager
James Coley	Sampling Preparation & Coordination
Karin Hoover	Scientist
Steve Kiesser	Scientist
Nancy P. Kohn	Scientist & Sample Tracking
Jack Q. Word	Chief Scientist
Manson Pacific Construction and Engineering	
Charles Gibson	Logistics Support, Barge-Vibracoring
Randy Morgan	Barge-Vibracoring
Keith Orr	Crane Operator for Barge-Vibracoring
Ruben Virgin	Barge-Vibracoring
Land and Sea Surveyors	
John Corona	Surveyor
Robert Dellaert	Surveyor
Westar Marine Services	
Bill Hammond	Deckhand, Vibratory Hammer Operator
Joe Wirth	Skipper, Bearcat
Slackwater Towboat Company	
Thomas Decker	Skipper, California Eagle

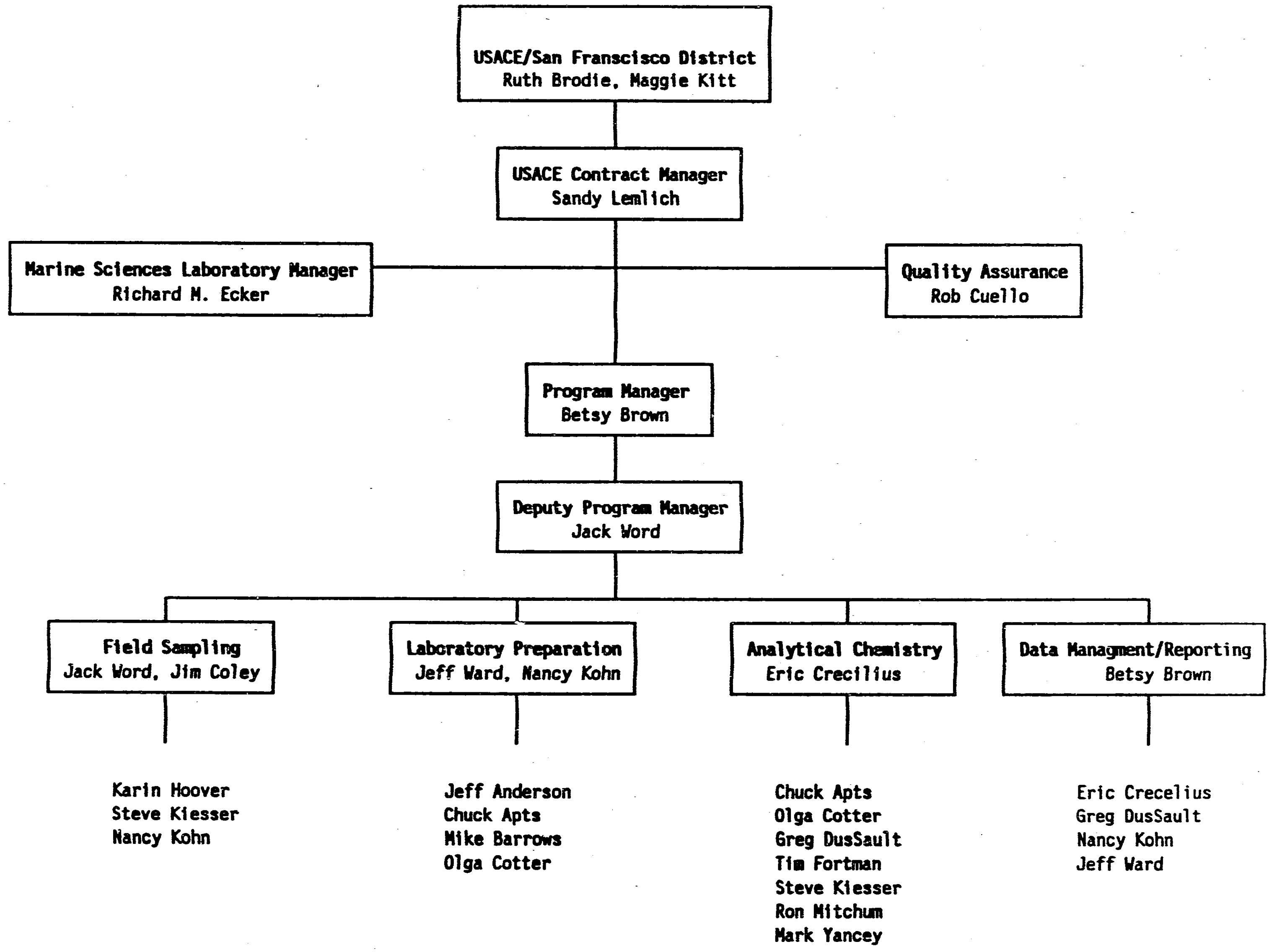

FIGURE 10. PROJECT ORGANIZATION

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APPENDIX A

CHAIN-OF-CUSTODY AND SAMPLE PREPARATION FORMS

DATE: ____________

PAGE ___ OF ___
(Continue
numbering
between dates)

SEDIMENT SAMPLE CHAIN OF CUSTODY
BATTELLE PACIFIC NORTHWEST
USACE RICHMOND HARBOR PROJECT

COLLECTION PERIOD: ____________________

NUMBER OF CORES LOADED ON TRUCK FOR PERIOD: ____________

TOTAL NUMBER OF CORES LOADED TO DATE: ____________

SAMPLE NUMBER	SECTION NUMBER	RELEASED BY/ DATE	ACCEPTED BY/ DATE

DATE: ______________ PAGE ___ OF ___

WATER SAMPLE CHAIN OF CUSTODY
BATTELLE PACIFIC NORTHWEST
USACE RICHMOND HARBOR PROJECT

COLLECTION PERIOD: ____________________________

NUMBER OF CARBOYS LOADED ON TRUCK FOR PERIOD: ______________

TOTAL NUMBER OF CARBOYS LOADED TO DATE: ______________

SAMPLE NUMBER	CARBOY NUMBER	RELEASED BY/ DATE	ACCEPTED BY/ DATE

BATTELLE Marine Sciences Laboratory
USACE Richmond Harbor Program

SAMPLE PREPARATION FORM

DATE ____________________

STATION ____________________

CORE SECTIONS ________________ ________________ ________________

________________ ________________ ________________

________________ ________________ ________________

________________ ________________ ________________

________________ ________________ ________________

________________ ________________ ________________

________________ ________________ ________________

________________ ________________ ________________

ANALYTICAL GROUP A B

SUBSAMPLE DESIGNATIONS:	Bulk Sediment	Elutriate	Interstitial
METALS/TOC	S-M-____ ____	E-M-____ ____	I-M-____ ____
ORGANOTIN/O&G	S-T-____ ____	E-T-____ ____	I-T-____ ____
ORGANICS	S-O-____ ____	E-O-____ ____	I-O-____ ____
PHYSICAL (USACE)	S-P-____ ____		

INITIALS ________________

COMMENTS

____

____

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____

____

____

BATTELLE Marine Sciences Laboratory
USACE Richmond Harbor Program

SAMPLE PREPARATION FORM

DATE ____________________

STATION ____________________

CORE SECTIONS

________________	________________	________________
________________	________________	________________
________________	________________	________________
________________	________________	________________
________________	________________	________________
________________	________________	________________
________________	________________	________________
________________	________________	________________

ANALYTICAL GROUP A B

SUBSAMPLE DESIGNATIONS:	Bulk Sediment
METALS/TOC	S-M-____ ____
ORGANOTIN/O&G	S-T-____ ____
ORGANICS	S-O-____ ____
PHYSICAL (USACE)	S-P-____ ____

INITIALS ______________

COMMENTS

____
____
____
____
____
____

CHEMISTRY SAMPLE CUSTODY FORM

PAGE ___ of ___

USACE RICHMOND HARBOR PROJECT
BATTELLE MARINE SCIENCES LABORATORY, 439 W. Sequim Bay Rd., Sequim, WA 98382, 206/683-4151; FAX 206/683-1059

SAMPLES SENT TO: ______________________
ORGANIZATION: ______________________
ADDRESS: ______________________
CITY, STATE, ZIP: ______________________

SAMPLE TYPE: ____________ ANALYSIS REQUESTED: ____________

SPECIAL INSTRUCTIONS: ______________________

Sample Number	Identification Number	Released By / Date	Accepted By / Date *

* Please sign, date, and send copy with original signature to:
Nancy P. Kohn, Battelle Marine Sciences Laboratory, 439 West Sequim Bay Road, Sequim, WA 98382, 206/83-4151

BATTELLE Marine Sciences Laboratory
USACE Richmond Harbor Program

Page ______ of

THERE WILL BE NO RETRIEVAL OF ARCHIVED CORE WITHOUT THE WRITTEN PERMISSION OF PROGRAM MANAGER

FREEZER INVENTORY

FREEZER	CORE LABEL	LENGTH	DATE IN	INITIALS	DATE OUT	PROJECT MANAGER INITIALS	INITIALS

APPENDIX B

GEOLOGICAL-DESCRIPTION METHODS AND DETAILED RESULTS

APPENDIX B

GEOLOGICAL DESCRIPTION METHODS AND DETAILED RESULTS

B.1 MATERIALS

The following is a checklist of items and materials useful for the examination and description of sediment cores.

- ASTM Procedure D 2488-84
- Stainless-steel knife
- Hand lens (10X magnification)
- 10 N Hydrochloric acid (HCl)
- Ruler (scaled in 0.1-foot increments)
- Blank log forms (see Figure B-1)
- Clipboard
- AGI Data Sheets
- Munsell Color Charts

In addition, the charts and/or reference materials listed in Table B- 1 are useful in the description of specific sediment characteristics.

B.2 METHODS

Descriptions of the physical, chemical, and biological features preserved in sediments aid in the interpretation of the types of geologic processes active both during and after the sediment was deposited. A total of 17 sediment characteristics, outlined in ASTM (1984), are commonly used to describe inorganic soils. These are listed in Table B-2.

Moisture condition was not routinely logged because of the saturated nature of the sediments. Furthermore, since particles were rarely larger than coarse sand, neither were angularity, particle shape, range in particle size, and hardness logged. For this reason, these sediment characteristics were not included in the log form for the description of Richmond Harbor sediments (Figure B-1). However, in the few instances where these characteristics did apply, they were described under the "COMMENTS" column.

TABLE B-1. Charts and Other Reference Materials Used to Provide Standardized Descriptions of Sediment Characteristics

CHART/REFERENCE	PURPOSE	FIGURE #
• Roundness Scale	Roundness of sand and coarser particles	B-2a
• Percentage Estimate Chart	Estimate percentage of individual particles or constituents	B-3
• Particle Shape	Reference to describe particle shape	B-4
• Munsell Soil Color Charts	Soil color	B-5
• Unified Soil Classification System	Method for designating sediment type	B-6, B-7
• Grain-size Scales	Range of particle sizes; maximum particle size	B-8, B-9
• Sorting Chart	Estimate of grading	B-2b
• Lithologic Symbols	Graphic patterns for lithologic log	B-10, B-11

TABLE B-2. Sediment Characteristics Identified in ASTM Procedure D2488-84.

1) angularity *
2) particle shape *
3) color
4) odor
5) moisture condition
6) HCl reaction
7) consistency (i.e., firmness)
8) cementation *
9) structure
10) sediment classification type (i.e., lithology)
11) range of particle sizes *
12) maximum particle size
13) hardness *
14) dry strength **
15) dilatancy **
16) toughness **
17) plasticity **

* Applies to coarse-grained sediment (sand and larger particles)

** Applies to fine-grained sediment of mostly silt and/or clay

Features not generally logged for this study are underlined.

The definition of "soil" from the engineers standpoint (ASTM 1984), includes any unconsolidated sediment. The geologic definition of soil is slightly different and restricts soils to those sedimentary deposits that have undergone alteration near the land's surface by either physical, chemical, and/or biological processes; therefore, in a strict sense, not all sediments are soils. For the purposes of this discussion, however, "soils" and "sediments" will be used synonymously.

It is sometimes helpful to provide an estimate of the relative proportions of different constituents in sediments (e.g. light- versus darkcolored minerals). This is made easier and more accurate by using a percentage estimate chart, which provides a graphic reference with varying concentrations of a particular constituent (Fig. B-2).

The criteria used to describe each of the 17 sediment characteristics identified in ASTM (1984) are discussed below.

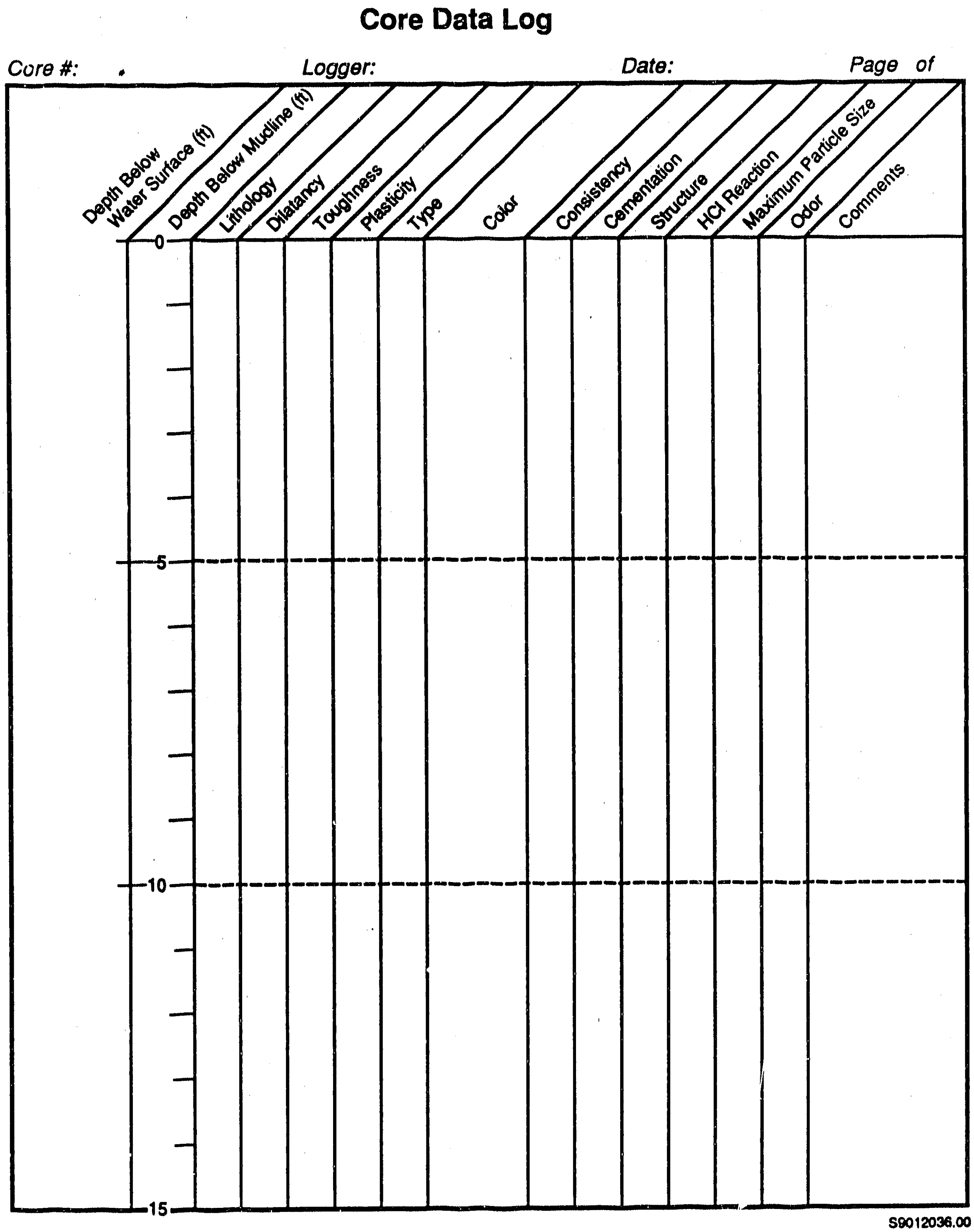
B.2.1 Angularity

The angularity of sedimentary particles is a reflection of the sedimentary environment and the amount of time that has elapsed before deposition and burial. A chart showing how to to classify the angularity of sedimentary particles is presented in Figure B-3a. A range of angularity may be stated, such as: subrounded to rounded.

B.2.2 Shape

Shapes of sedimentary particles often reflect the internal characteristics (e.g., preferential parting) of the material or sometimes the type of sedimentary environment. For example gravel clasts deposited in high-energy environments, such as beaches and river bottoms, are often worn flat.

According to Figure B-4, gravel-sized clasts may be described in one of four ways. First, if the ratio of the clast's width to thickness is >3, it is classified as flat. Second, if the ratio of the clast's length to B.5 width is >3, the clast is elongate. Third, if both criteria apply the clast is both flat and elongate. And last, if none of the criteria apply, then



Core Data Log

Core #:

Logger:

Date:

Page of

Depth Below Water Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Comments
	0													
	5													
	10													
	15													

S9012036.00

FIGURE B.1. Log Form Used to Record Sediment Descriptions

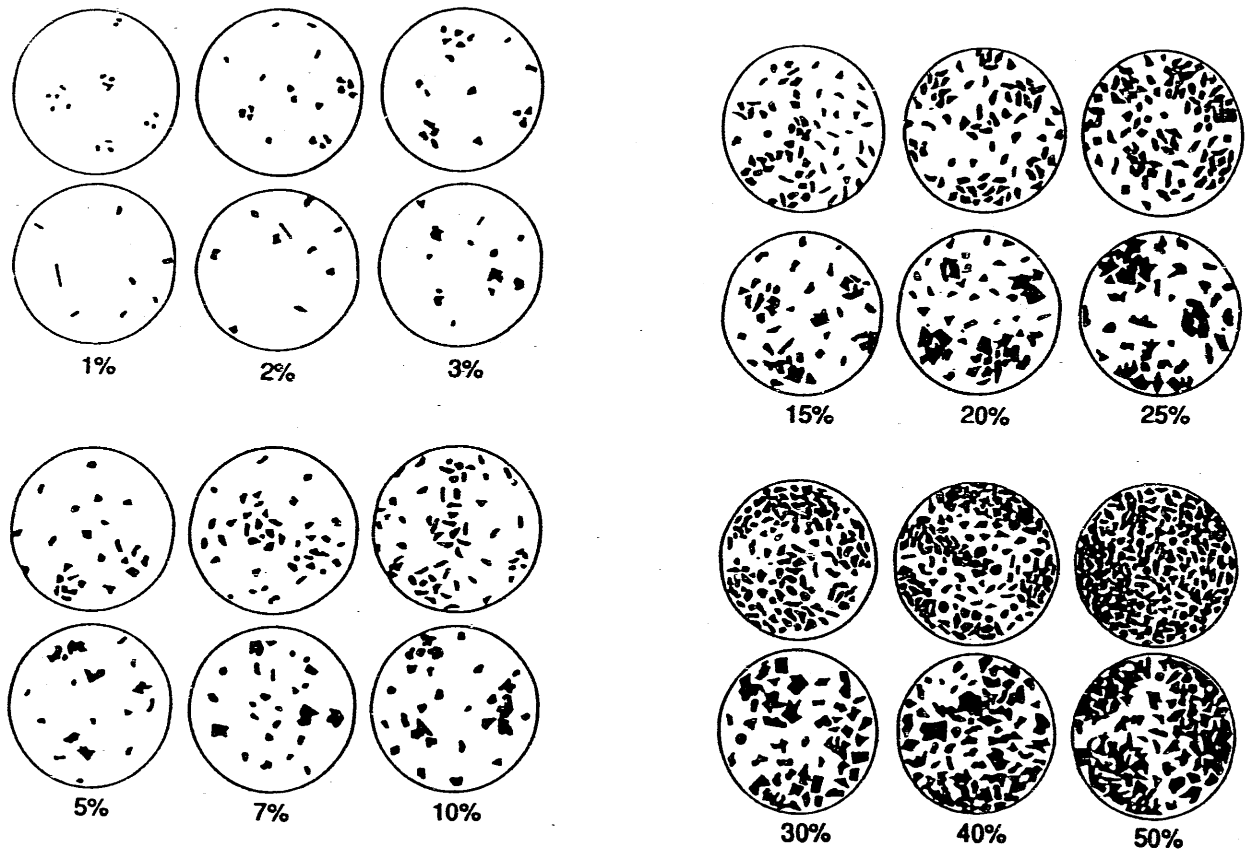


FIGURE B.2. Comparison chart used to estimate the percentages of constituents. From AGI (1982).

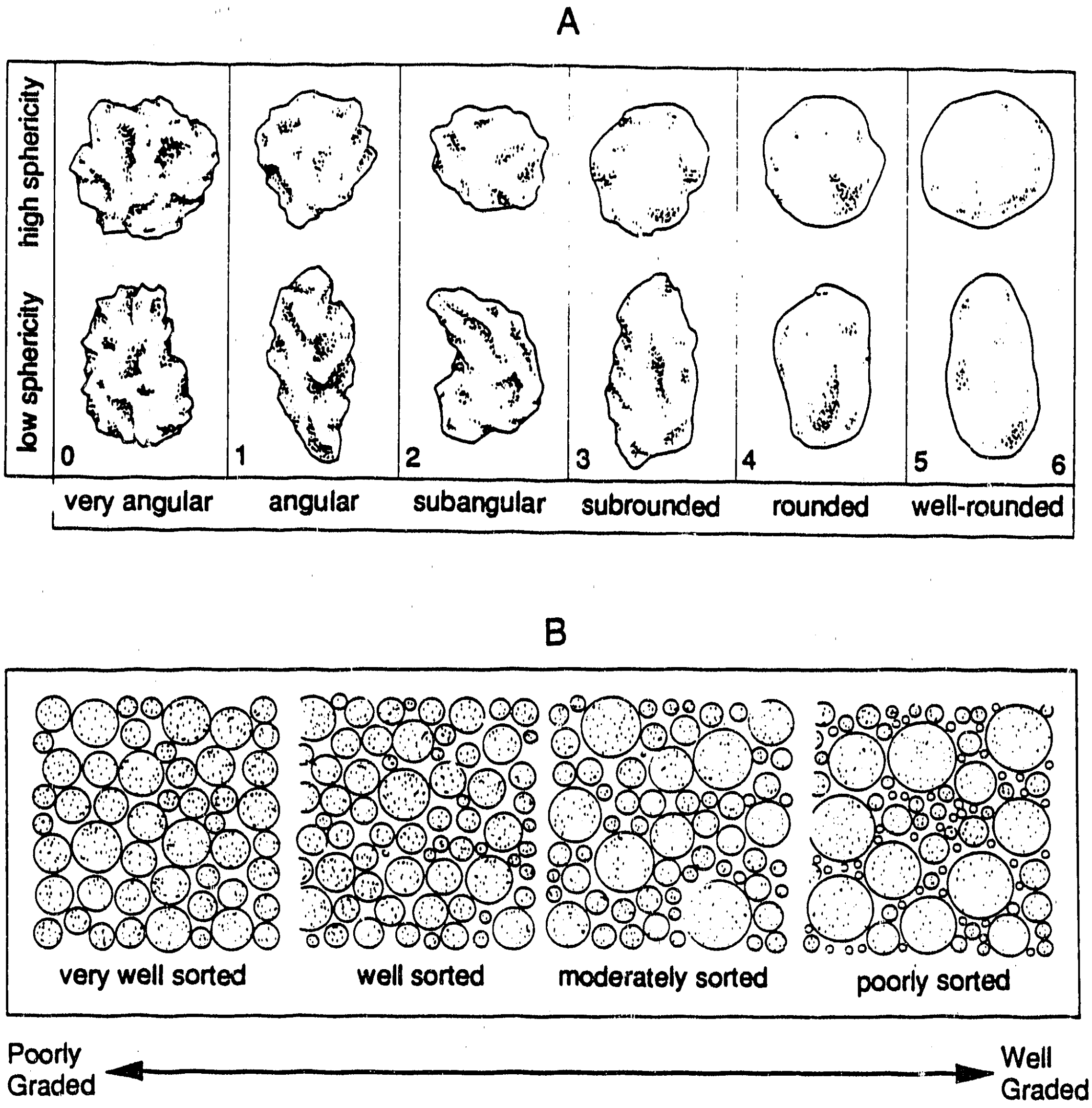
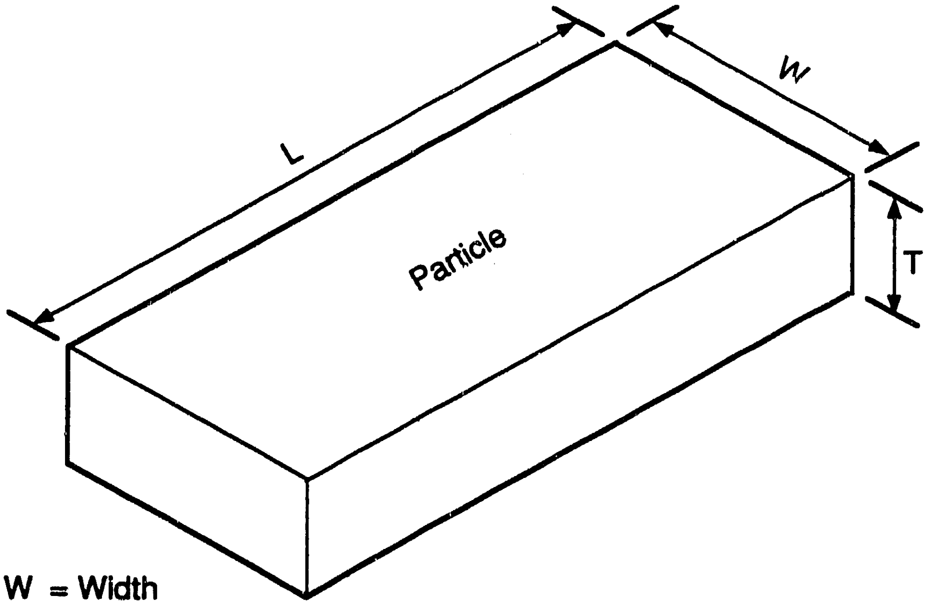


FIGURE B.3. Charts Used to Visually Estimate Roundness/Sphericity (A) and Sorting/Grading (B)



W = Width
T = Thickness
L = Length

Flat: W/T>3
Elongated: L/W>3
Flat and Elongated: meets both criteria

S9012061.3

FIGURE B.4. Criteria Used to Describe Particle Shape From ASTM (1984) shape is not mentioned. One indicates the fraction of the clasts that have the shape, such as: one-third of gravel clasts are flat. Particle shape did not apply to most of the sediments logged during this project and the few pebbles that were observed were neither flat nor elongate.

B.2.3 Color

Color may be useful in identifying materials of similar geologic origin. For example, color was often a useful criteron for differentiating Younger Bay Mud from Older Bay Mud. Sediment color was determined by comparing the wet sediment with standard sediment colors given in Munsell (1975). The advantage to using the Munsell soil color system is that it provides a consistent, standardized method for describing color and that subjectivity is minimized.

The Munsell color notation consists of three simple variables that combine to describe all colors known in the Munsell soil color system. The three variables are: hue, value, and chroma (Figure B-5). The hue notation indicates the relation of the sediment color with respect to red, yellow, green, blue and purple; the value notation indicates its lightness; and the chroma notation indicates its strength (i.e., intensity).

Color can be described either by the Munsell notation (e.g., 5YR 5/3; hue=5YR, value=5, chroma=3) or by its equivalent color name (e.g., reddish brown). Both the color name and Munsell notation were recorded on core logs. Only rarely was there not a reasonable match between the true color of the core sediment and one of the colors on a Munsell color chart.

B.2.4 Odor

Odors may indicate the presence of contaminants or they may be the result of the eochemical environment. Odors most frequently noted were the odor of petroleum hydrocarbons and the smell of rotten eggs (an indication of the presence of hydrogen sulfide). Both of these odors were restricted to the Younger Bay Mud unit. Petroleum odors may be the result of contamination of sediments by shipping spills or industrial waste, or perhaps are derived from the abundant decaying organic matter present in these sediments. Hydrogen sulfide is a common natural by-product in chemically reducing environments such as the Richmond Harbor estuary.

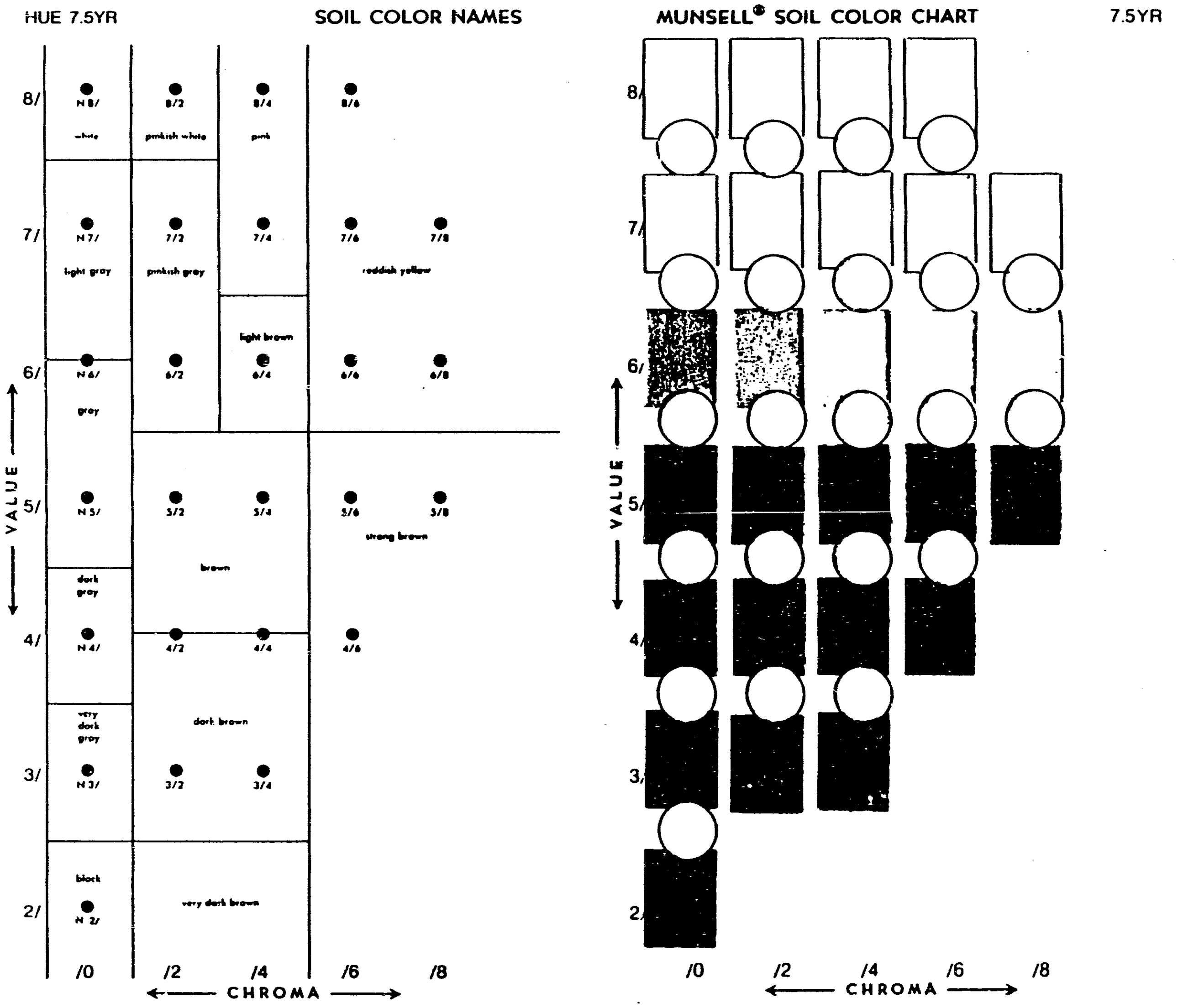


FIGURE B.5. Example of a page from the Munsell Soil Color Chart for Hue 5YR. Color chips used to estimate soil color are on the right.

B.2.5 Moisture Condition

Moisture condition is described as either dry, moist, or wet according to the following criteria:

DRY	Absence of moisture, dry to the touch
MOIST	Damp but no visible water
WET	Visible free water, usually soil is below water table (i.e.,saturated)

All the sediments logged for this project were taken from below sea level and did not lose any significant moisture between the time they were drilled and logged. Therefore, they are all classified as wet.

B.2.6 HCl Reaction

The reaction (i.e., effervescence) of sedimentary material, as a result of adding dilute hydrochloric acid, is an indication of the presence of calcium carbonate. Calcium carbonate in sediments may be derived from a variety of sources including: 1) physical disintegration of preexisting carbonate rocks (e.g., limestone, marble), 2) biogenic precipitation (e.g., shell, bone), and 3) soil development. In the last example, calcium carbonate concentrations, often referred to as caliche or calcrete, may accumulate over time near the land's surface in arid climates. Where calcium carbonate concentrations occur in combination with other evidence for soil development, such as root traces and oxidation, then a pedogenic (soil forming) origin is favored. Criteria for describing the reaction with 10 N HCl are as follows:

NONE	No visible reaction
WEAK	Some reaction, with bubbles forming slowly
STRONG	Violent reaction, with bubbles forming immediately

A solution of 10 N HCl is obtained by slowly adding one part of concentrated hydrochloric acid to three parts of distilled water.

B.2.7 Consistency

Consistency is a measure of the firmness or consolidation of sedimentary material. In general, there is a direct relationship between consistency and age of the deposit (i.e., older deposits are usually more firm because of compaction and/or cementation).

Consistency is most applicable to fine-grained sediments and least applicable on sediments that contain significant amounts of gravel. The criteria used to determine consistency are as follows:

VERY SOFT	Thumb will penetrate soil more than 1 inch (25 mm)
SOFT	Thumb will penetrate soil about 1 inch (25 mm)
FIRM	Thumb will indent soil about 1/4 inch (6 mm)
HARD	Thumb will not indent soil but readily is readily indented with thumbnail
VERY HARD	Thumbnail will not indent soil

B.2.8 Cementation

Often sedimentary particles are held together with a binding cement. Three common natural cements are calcium carbonate (lime), silica, and ironoxide compounds. Particles cemented with calcium carbonate effervesce in the presence of hydrochloric acid (see Section B.2.6 above). Sediments cemented with iron oxide are usually some shade of red, yellow, or brown. Usually there is a relationship between consistency (Section B.2.7) and cementation, in that strongly cemented deposits are also hard to very hard. Criteria used to describe the degree of cementation are:

WEAK	Crumbles or breaks with handling or light finger pressure
MODERATE	Crumbles or breaks with considerable finger pressure
STRONG	Will not crumble or break with finger pressure

B.2.9 Structure

Structures are features that originate within the layers of sediment or at the sediment/water interface in response to various physical, biologic and/or chemical processes. Structures may be classified into two categories: primary and secondary. Primary structures form as the sediment is being deposited (e.g., lamination, stratification). Secondary structures form after deposition, often as a result of compaction or other stresses (e.g., fissured, slickensided), biologic activity (e.g., root traces, mottling), and soil development (e.g., homogeneous, blocky, mottled). The following are some common structures observed in sedimentary deposits.

PRIMARY STRUCTURES

STRATIFIED	Alternating layers of varying material or color with layers at least 6 mm thick
LAMINATED	Alternating layers of varying material or color with the layers less than 6 mm thick
LENSED	Inclusion of small pockets of different sediment type, such as small lenses of sand scattered through a mass of clay. (This type of structure may also be secondary)

SECONDARY STRUCTURES

FISSURED	Breaks along definite planes of fracture with little resistance to fracturing
SLICKENSIDED	Fracture planes appear polished or glossy, sometimes striated
BLOCKY	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
MOTTLED	Variation in color of sediments as represented by localized spots or blotches of color or shades of color
HOMOGENEOUS	Same color and appearance throughout

B.2.10 Sediment Classification Type

The classification method used in this study is the Unified Soil Classification System (Fig. B-6), which consists of a two-letter designation for most soils (i.e., unconsolidated sediments). A simplified version of the Unified Soil Classification System is presented in Figure B-6, while a moredetailed breakdown is presented in Figure B-7. According to this classification system, coarse-grained sediments are classified based on grain-size distribution and grading (i.e., sorting), while fine-grained sediments are classified on the basis of grain size and liquid limit vs. plasticity.

Particle-size distribution may be determined with precision using laboratory methods (e.g., sieving of sand and coarser particles; pipette or hydrometer analysis of silt and clay). Because these methods are expensive

Major Divisions			Group Symbols	Description
Coarse-Grained Sediments More than half of particles are larger than very fine sand	≥50% Gravel	Clean Gravels	GW	Well-graded (i.e., poorly sorted) gravels, gravel-sand mixtures, little or no fines
			GP	Poorly graded (i.e., well sorted) gravels, gravel-sand mixtures, little or no fines
		Gravels with Fines	GM	Silty gravels, gravel-sand-silt mixtures
			GC	Clayey gravels, gravel-sand-clay mixtures
	≥50% Gravel	Clean Sands	SW	Well-graded sands, gravelly sands, little or no fines
			SP	Poorly graded sands, gravelly sands, little or no fines
		Sands with Fines	SM	Silty sands, sand-silt mixtures
			SC	Clayey sands, sand-clay mixtures
Fine-Grained Sediments More than half of particles are smaller than very fine sand	Silts and Clays	Low Liquid Limit	ML	Silts and very fine sands, silty or clayey fine sands, or clayey silts, with slight plasticity
			CL	Clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
		High Liquid Limit	MH	Silts or fine sandy silts with moderate plasticity
			CH	Clays of high plasticity, fat clays

FIGURE B.6. Abbreviated form of the Unified Soil Classification System. From AGI (1982).

and time-consuming, it is more desirable to estimate grain size using rapidvisual-manual techniques described below. For example, sand and coarser particles are most easily identified via comparison with standard charts of grain size (Figs. B- 8 and B-9). Fine-grained soils, consisting of mostly silt and/or clay, on the other hand, are identified based on manual tests of their dry strength, dilatancy, toughness, and plasticity (Figure B-10).

In the Unified Soil Classification System (Figs. B-6 and B-7), the first letter of the sediment-type symbol represents the predominant grain-size interval, be it gravel (G), sand (S), silt (M), or clay (C). For coarsegrained sediments, the first letter (i.e., G or S) may be followed by a descriptor of grading, either W (well graded) or P (poorly graded), or a secondary grain-size descriptor (M or C). The definition of grading is opposite that of sorting, a common geologic term. For example, a clean, well-sorted sand, consisting of particles over a narrow range in grain size, is referred to as poorly graded in the Unified Soil Classification System and would receive the designation "SP". The relationship between grading and sorting is shown graphically in Figure B-3b. The second letter in the fine-grained soil designation consists of either L (low liquid limit) or H (high liquid limit).

The lithology column on the geologic log (Fig. B-1) essentially represents a graphic display of sediment type. The graphic displays of lithology are utilized for quick easy reference and comparison between different cores and thus make interpretations easier. The symbols used for the Richmond Harbor sediments are shown in Fig. B-11. Examples of other lithologic symbols in common use are presented in Fig. B-12. Additional symbols may be used as long as they are graphically representative of the feature and are specifically defined and identified in a key that accompanies lithologic logs.

B.2.11 Range of Particle Sizes

For gravel- and sand-sized particles, the range of particle sizes within each component is defined. For example, 20% fine to coarse gravel, 40% fine to coarse sand. The sizes of particles corresponding to the different ize components are presented in Figures B-8 and B- 9.

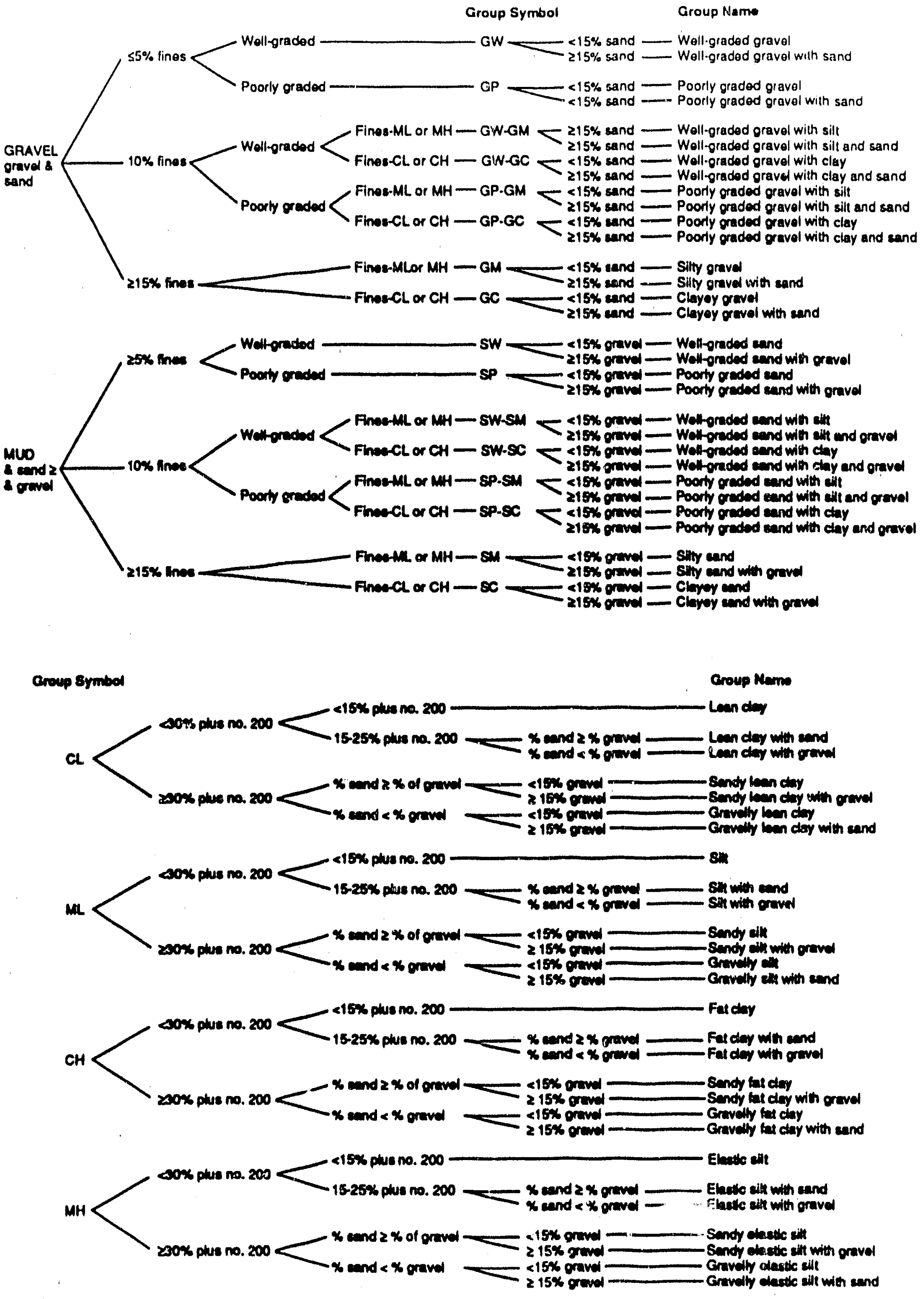


FIGURE B.7. Detailed Flow Chart for the Classification of Coarse-grained (A) and Fine-grained (B) Soils Using the Unified Soil Classification System.

Grade Limits			Inches	U.S. Standard Sieve Series	Grade Name		
phi	mm	mm					
-12	4096		161.3		very large	Boulders	GRAVEL
-11	2048		80.6		large		
-10	1024		40.3		medium		
-9	512		20.2		small		
-8	256		10.1		large	Cobbles	
-7	128		5.0		small		
-6	64		2.52	63 mm	very coarse	Pebbles	
-5	32		1.26	31.5 mm	coarse		
-4	16		0.63	16 mm	medium		
-3	8		0.32	8 mm	fine		
-2	4		0.16	No. 5	very fine		
-1	2		0.08	No. 10	very coarse	Sand	SAND
0	1		0.04	No. 18	coarse		
+1	1/2	0.500		No. 35	medium		
+2	1/4	0.250		No. 60	fine		
+3	1/8	0.125		No. 120	very fine		
+4	1/16	0.062		No. 230	coarse	Silt	MUD
+5	1/32	0.031			medium		
+6	1/64	0.016			fine		
+7	1/128	0.008			very fine		
+8	1/256	0.004			coarse	Clay Size	
+9	1/512	0.002			medium		
+10	1/1024	0.001			fine		
+11	1/2048	0.0005			very fine		
+12	1/4096	0.00025					

FIGURE B.8. Grain-size scales used to determine sedimentary particle size.

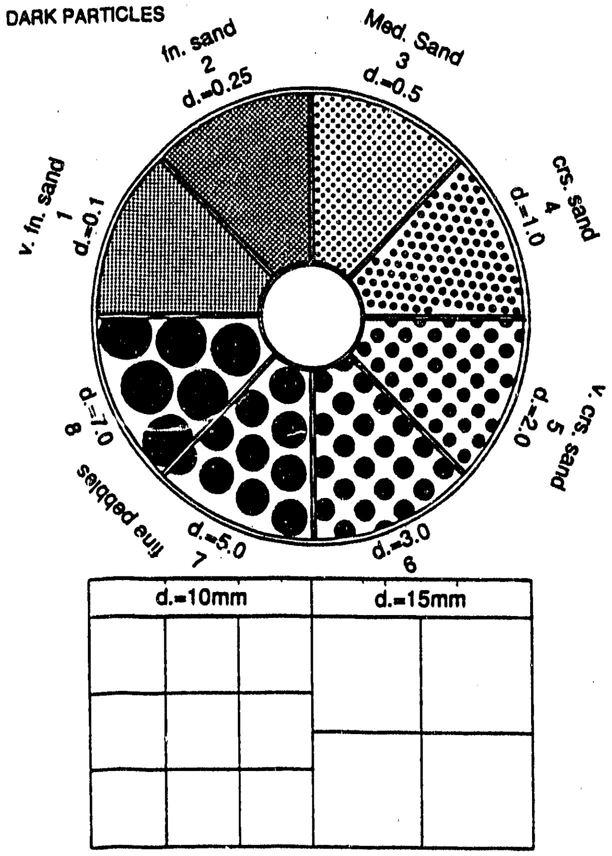


FIGURE B.9. Comparison chart used to distinguish among sand to pebble-size particles. From AGI (1982). For larger particles, refer to Figure B.8; for smaller particles, refer to sections B.2.13 and B.2.16 in this Appendix.

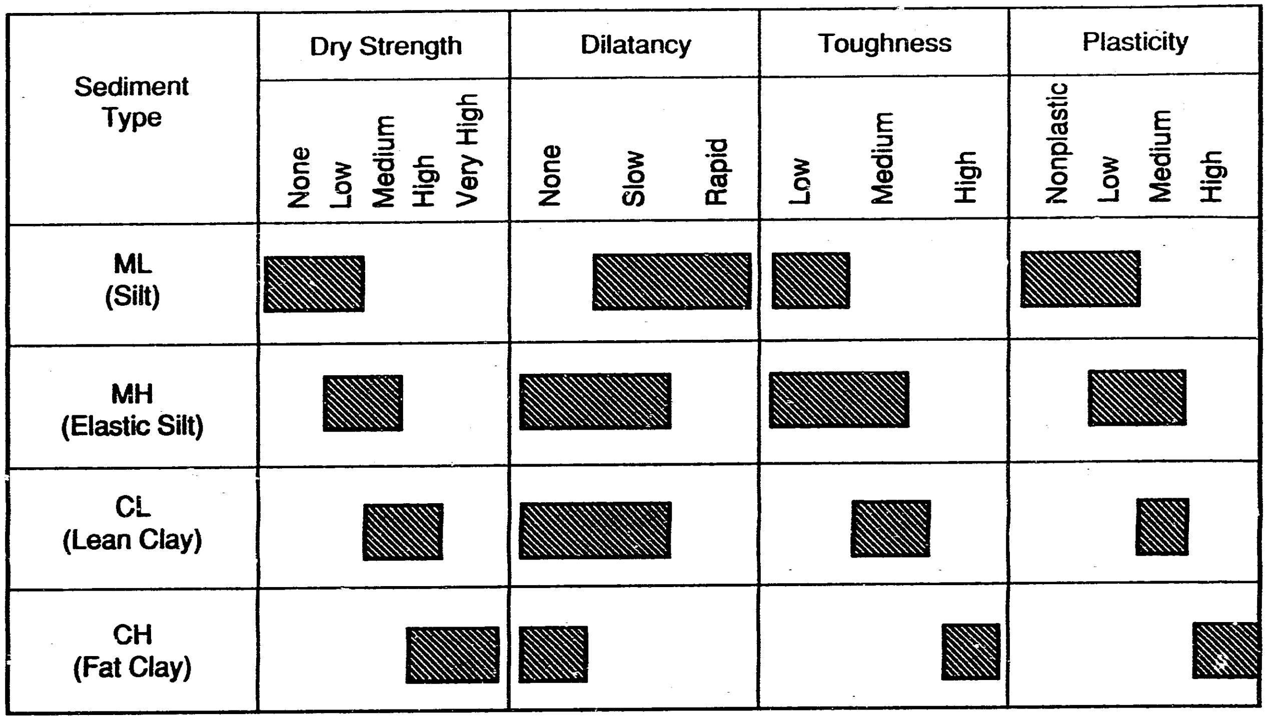


FIGURE B.10. Identification of inorganic fine-grained soils from manual tests.

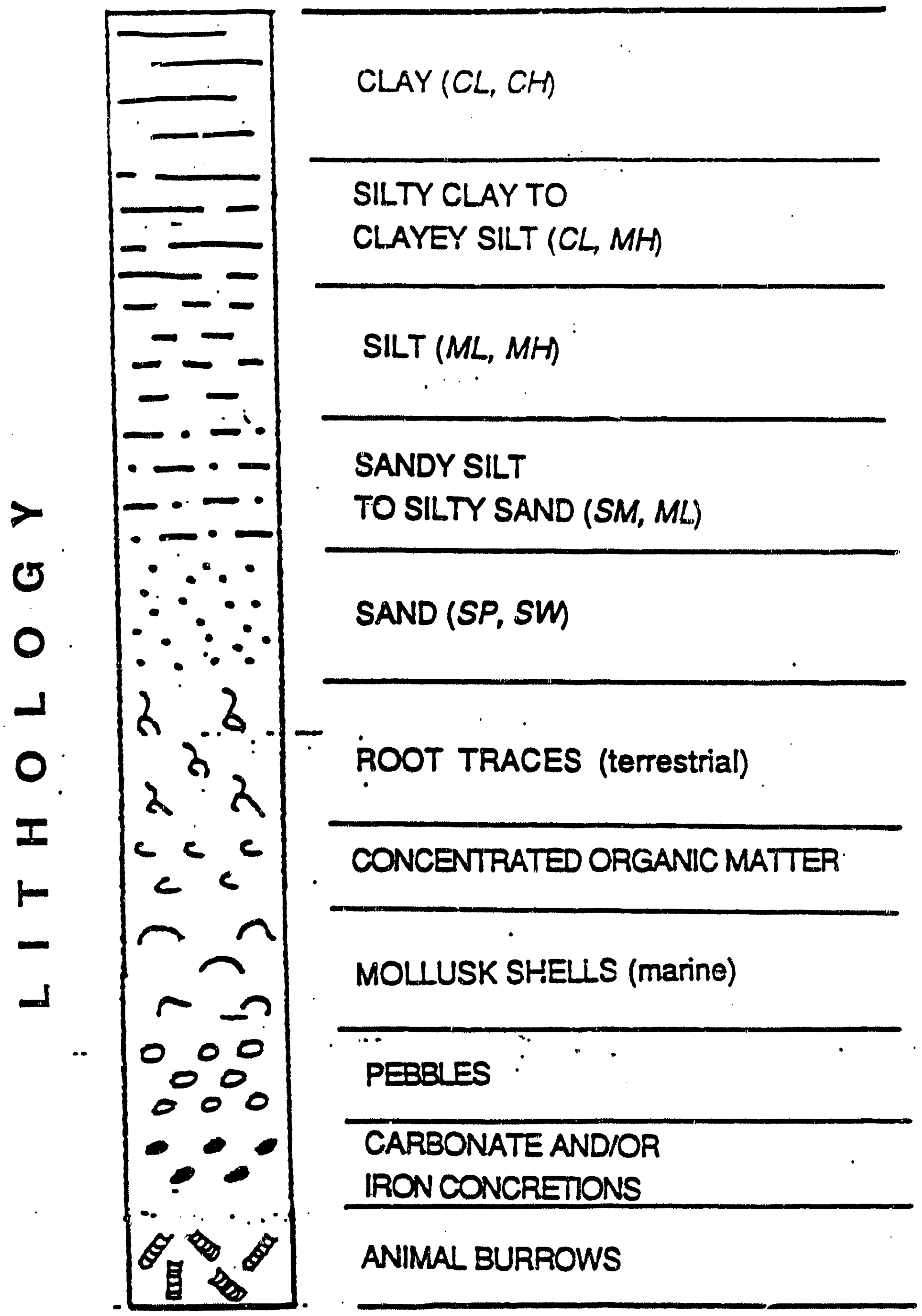


FIGURE B.11. Symbols used to represent different lithologic properties on core logs in Appendix B.

B.2.12 Maximum Particle Size

Maximum particle size is significant because it gives a general indication of the amount of turbulence or energy associated with deposition. If the maximum particle size is sand, it should be described as either fine, medium, or coarse sand. If the maximum particle size is in the gravel range, the largest particle is measured and its width recorded along the narrowest axis. The sizes of particles corresponding to the different size components are presented in Figures B-8 and B-9.

The maximum grain size observed for the Younger Bay Muds ranged from silt to medium sand, while the Older Bay Mud usually ranged from fine sand to coarse sand. The largest particles observed anywhere were fine pebbles in the Older Bay Mud unit.

B.2.13 Dry Strength

Dry strength, dilatancy, toughness, and plasticity are physical characteristics used to distinguish fine-grained inorganic soils, consisting of mostly silt and/or clay. Basically, the more clay present in a soil the greater its dry strength (Fig. B-10). To perform a manual test of dry strength, enough material must be selected in order to mold into a ball about 1 in. in diameter. The material is molded until it has the consistency of putty, adding water if necessary. From the molded material, at least three test specimens each about 1/2 in. in diameter are made. The specimens are allowed to dry in air, sun or by artificial means, as long as the temperature does not exceed 60C (ASTM 1984). The criteria for determining dry strength are as follows:

NONE	The dry specimen crumbles into powder with mere pressure of handling
LOW	The dry specimen crumbles into powder with light finger pressure
MEDIUM	The dry specimen breaks into pieces or crumbles with considerable finger pressure

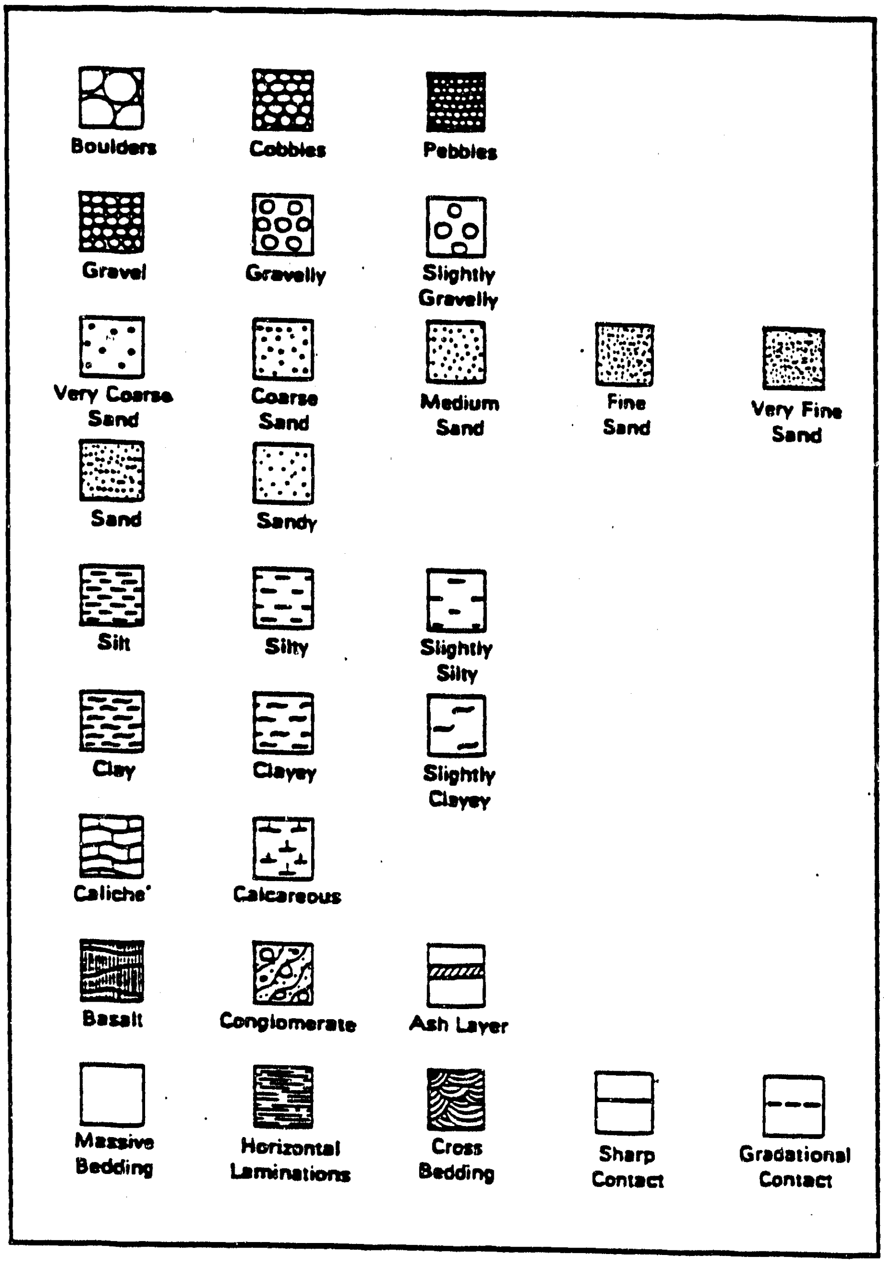


Figure B.12. Additional lithologic symbols in common use.

HIGH	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface
VERY HIGH	The dry specimen cannot be broken between the thumb and a hard surface

Dry strength was determined for Richmond Harbor cores by sampling selected intervals and allowing the samples to air dry overnight. Dry strength was determined the next day and noted in the comments column of the geologic log.

B.2.14 Dilatancy

Dilatancy is a measure of how easily a soil gives up water when shaken. For example, some clays have the ability to absorb and retain large amounts of water into their crystal lattice. "Fat" clays tend to retain their water even under stress, whereas "lean" clays and silt tend to release water when shaken.

To test for dilatancy enough material to mold into a ball about 1/2 in. in diameteris selected. The material is molded, adding water if necessary, until it has a soft, but not sticky, consistency. The soil ball is smoothed in the palm of the hand with a blade of a knife or small spatula. The soil then is horizontally by striking the side of the hand vigorously against the other several times. The reaction of water appearing on the surface of the soil is observed. The sample is squeezed by closing the hand or pinching the soil between the fingers, noting the reaction. Specimens with high dilatancy will quickly yield water when shaken and absorb water when squeezed. The criteria for describing dilatancy are:

NONE	No visible change in the specimen
SLOW	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing
RAPID	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

The range of dilatancy for the different fine-grained sediment types is shown in Figure B-10. From this figure it is apparent that dilatancy decreases with decreasing grain size.

B.2.15 Toughness

After completion of the dilatancy test, the same specimen is shaped into an elongated pat and rolled by hand on a smooth surface or between the palms into a thread about 1/8 in. (3 mm) in diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) The sample threads are folded and the sample is rerolled repeatedly until the thread crumbles at a diameter of about 1/8 in. The thread will crumble at a diameter of 1/8 in. when the soil is near the plastic limit. The pressure required to roll the thread near the plastic limit is noted. Also, the thread strength is noted. After the thread crumbles, the pieces are lumped together and kneaded until the lump crumbles. The toughness of the material during kneading is noted and the sample is classified into one of the following categories:

LOW	Only slight pressure is required to roll the thread near the plastic limit. The thread and lump are weak and soft.
MEDIUM	Medium pressure is required to roll the thread to near the plastic limit. The thread and lump have medium stiffness.
HIGH	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness.

The range of toughness for the different fine-grained sediment types is shown in Figure B-10. From this figure it is apparent that toughness increases with a decrease in particle size.

B.2.16 Plasticity

On the basis of observations made during the toughness test, the plasticity of the material is described according to the following criteria:

NONPLASTIC	A 1/8 in. thread cannot be rolled at any water content.
LOW	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
MEDIUM	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.

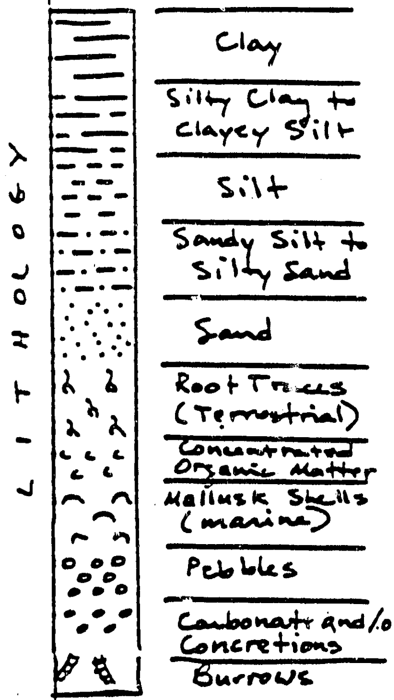
HIGH	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

The range of plasticity for the different fine-grained sediment types is shown in Figure B-10. From this figure it is apparent that an increase in plasticity accompanies a decrease in grain size.

B.3 RICHMOND HARBOR CORE LOGS

Richmond Harbor core logs are shown in the following pages. A key to the symbols used on the core logs is followed by the detailed descriptions for each Richmond Harbor long core. The arrows in the "depth below mudline" column show the divisions between vertical sections that were sampled for chemistry. These descriptions also show where changes in sediment characteristics were used to differentiate between the Older Bay Mud and Younger Bay Mud units.

KEY TO CORE LOG : After ASTM Procedure D2488-84



CLAY/SILT CHARACTERISTICS

Dilatancy:
N = None
S = Slow
R = Rapid

Toughness:
L = Low
M = Medium
H = High

Plasticity:
N = None
L = Low
M = Medium
H = High

Type:
See ASTM D2488-84

V = Variable

→ Core segment division

Color: According to Munsell Soil Color Chart (All colors are wet)

Consistency:
VS = Very soft
S = Soft
F = Firm
H = Hard
VH = Very Hard

Cementation:
N = Not cemented
W = Weakly cemented
M = Moderately cemented
S = Strongly cemented

Odor:
S = Sulfide
P = Petroleum

Structure:
S = Stratified
L = Laminated
F = Fissured
Sl = Slickensided
Ln = Lensed
Bl = Blocky
M = Mottled
H = Homogeneous

HCl Reaction:
N = None
W = Weak
S = Strong

Maximum Particle Size:
CS = Coarse Sand
MS = Medium Sand
FS = Fine sand
Z = Silt

Core #: RI-1-W-i
Date: 4/17/89
Page 1 of 1

Core drilled = 25
Core received = 2'
Mud line depth
below MLLW = 20.1

Depth Below H₂O Surface	Depth Below Mudline	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Comments
		*	V	V	V	V	Very dark gray (5Y 3/1) to light olive brown (2.5Y 5/4)	V	N	M	N	cobble	N	
	15'	▨												
		▨												

* Mixture of gravel (~10%), sand (~30%) and mud (~60%). Mud clumps predominate. Large angular cobbles and pebbles. One specimen yeilded high dry strength (i.e. high clay content). Older Bay mud probably present due to presence of oxidized color.

Core #: RI - 1 - TC - 1
Date: 4/17/89
Page 1 of 2

Core drilled = 33.8
Core received = 23'
Mud line depth below MLLW = 52'

0-2.9
2.9-9.3
9.3-19.2
19.2-23.0
} Composite sample intervals

Depth Below H2O Surface	Depth Below Mudline	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Comments
			S	L	L	ML	Dark gray (5Y 4/1)	VS S	N	H	N	VFS Z	S	
							Olive gray (5Y 4/2)							Low dry strength
10	5													
														stiffer
15	10													Gas voids
														Low dry strength
						SW	Very dark gray (5Y 3/1)					MS		subrounded-subangular

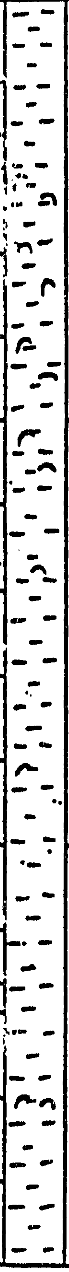
Core #: RI-11-TC-1
Date: 4/17/89
Page 2 of 2

Depth Below H2O Surface	Depth Below Mudline	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Comments
→			S ↓	L ↓	M ↓	MH ↓	Dark gray (5Y 4/1) ↓	S ↓	N ↓	H ↓	N ↓	Ƶ		Gas voids ↓ medium dry strength ↓ Younger Bay Mud
			—	↓ M	L M	ML ↓ CL	Grayish brown (2.5Y 5/2) Gray (5Y5/1)	F	—	S	—	FS ↓ Ƶ	—	Older Bay Mud
25	20		↓	↓ L ↓	↓ L ↓	↓ ML ↓ SW ↓	↓ Dark gray (5Y 4/1) ↓ Olive brown (2.5Y 4/4) ↓	↓	↓	↓	↓	↓ FS ↓ pebble ↓		Gradational ↓ rounded to sub-angular
30	25													

Core #: RI-1-TC-2
Date: 4/18/89
Page 1 of 2

Core drilled = 34.8'
Core received = 21.6
Mud line depth below MLLW = 5.2'

0-2.0
2.0-6.7
6.7-16.6
16.6-21.6
} Composite sample intervals

Depth Below H2O Surface	Depth Below Mudline	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Comments
			S	L	L	ML	Olive gray (5Y 4/2) Dark gray (5Y 4/1)	VS ↓ S	N	H	N	FS Z	N	
10	5													
15	10												↓ S	

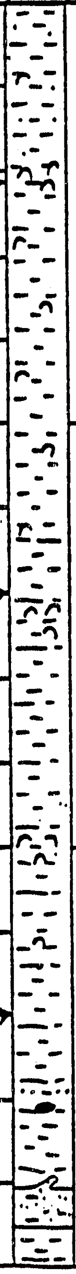
Core #: RI-1-TC-2
Date: 4/18/89
Page 2 of 2

Depth Below H_2O Surface	Depth Below Mudline	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Comments
			S	L	L	ML	Dark gray (5Y 4/1)	S	N	H	N	Z	S	Younger Bay Mud
						SP				S		FS	N	
			S	L	L	ML	Dark gray (2.5Y 4/0)			H		Z		Older Bay Mud organic-filled roots and mats;
25	20			M	H	CL	Very dark gray (2.5Y 3/0)	F	N-S					Mud concretions, drop stones
	25													

Core #: RI-1-TC-3A
Date: 4/17/89
Page 1 of 2

Core drilled =
Core received = 22'
Mud line depth
below MLLW = 6.9'

2.1 - 10.3
10.3 - 18.7
18.7 - 22.0
} Composite sample intervals

Depth Below H_2O Surface	Depth Below Mudline	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reacion	Maximum Particle Size	Odor	Comments
10			S ↓	L ↓	L ↓	ML ↓	Dark gray (5Y 4/1) ↓ Olive gray (5Y 4/2) ↓	VS ↓ S	N	H ↓	N	VFS ↓ Z ↓	N	
15	5		↓	↓	↓ M ↓	↓ MH ↓	↓			↓		↓		Gas voids stiffer ↓
20	10		↓ S ↓ S	↓ L ↓ L	↓ M ↓ M	↓ SW MH ↓ SW ↓ MH	↓ Gray (5Y 5/1) ↓ Dark gray (5Y 4/1)			↓ L H		VFS ↓ Z ↓ FS Z ↓ FS ↓ Z		Shell hash iron concretion medium dry strength soft-sediment deformation

Core #: RI-1-TC-3A
Date: 4/17/89
Page 2 of 2

Depth Below H_2O Surface	Depth Below Mudline	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Comments
			S	L	M	MH	Dark gray (5Y 4/1) Gray (5Y 5/1)	S	N	H	N	Z	N	medium dry strength Younger Bay Mud
					L	ML	Olive gray (5Y 5/2)	F			W	FS		Older Bay Mud
	20					SW	Dark grayish brown (2.5Y 4/2) Olive brown (2.5Y 4/4)			S/L	N	CS		subangular-subrounded
	25													

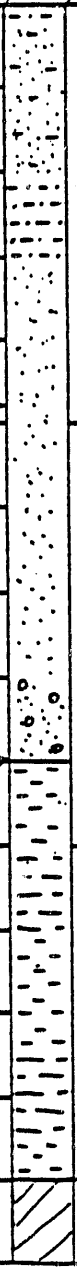
Core #: RI-1-TC-4
Date: 4/18/09.
Page 1 **of** 2

Core Received = 29.0'
Mudline Depth below MLLW = 6.2'

2.0-8.8',
8.8-18.0',
18.0-29.0'
} Composite sample intervals

Depth Below H₂O Surface (ft)	Depth Below Mudline (ft)	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Comments
			S	L	L	ML	very dark gray (5Y 3/1) dark gray (5Y 4/1)	VS S	N	H	N	FS Z	N	
10														
	5													Shell hash
15														Younger Bay Mud
			S	M	M	CL	gray (5Y 5/1)	F		M				Older Bay Mud Gradational
	10						light olive brown (2.5Y 5/4)							medium dry strength
							yellowish brown (10YR 5/8)	S	N-S N	H	N-S N			Mud concretions
20				L	L	ML								

Core #: RI-1-TC-4
Date: 4/18/89
Page 2 of 2



Depth Below H$_2$O Surface	Depth Below Mudline	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Comments
			S	L	L	ML SW	yellowish brown (10YR 5/8)	S	N	H	N	FS	N	
			S ↓	L ↓	L ↓	ML								
						SW	dark yellowish brown (10YR 4/4)	F		L/S				
25														
												MS		
	20													
												CS		
							dark brown (10YR 3/3)					pebble		
30														
			S	L	L	ML	Yellowish brown (10YR 5/4)			H		[illegible]		
	25			M	M	CL								
						ML								
						CL	Grayish brown (10YR 5/2)							
35							lt olive brown (2.5Y 5/4)							

Core #: RI-1-TC-5
Date: 4/17/89
Page 1 of 2

Core drilled = 18.9'
Core received = 17'
Mudline depth below MLLW = 20.1

0-2.3',
2.3-5.0',
5.0-8.3',
8.3-11.5',
11.5-17.0'
Composite sample intervals

[illegible] Below H_2O Surface	Depth Below Mudline	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Comments
			S	L	L	ML	Olive (5Y5/3) and very dark gray (5Y 3/1)	VS	N	M	N	FS	P	
							Very dark gray (5Y3/1)					Z		
								S						
						SP	H. olive brown (2.5Y 5/4)			S		MS		
			S	L	L	ML	Dark gray (5Y 4/1)			M		Z		
	5													Low dry strength
														Younger Bay Mud
					M	CL	Gray (5Y 5/1)	F ↓ S		S			N	Older Bay Mud ↑
					L	ML	V. dark grayish brn (2.5Y 3/2)			H				marine terrestrial
														↓ Gradational sgt. blue-clay aggregates
	10									Bl				
					M	CL	Gray (2.5Y 5/0)	H		H				
											W			carbonate and iron concretions. medium dry str.
					L	ML	Gray (2.5Y5/0) and H. olive brown (2.5Y 5/4)	F		M		FS		

Core #: RI-1-TC-5
Date: 4/17/89
Page 2 of 2

Depth Below H2O Surface	Depth Below Mudline	Lithology	Dilatancy	Toughness	Plasticity	Type	Color	Consistency	Cementation	Structure	HCl Reaction	Maximum Particle Size	Odor	Comments
			S ↓	L ↓	L ↓	ML ↓ SW	gray (2.5Y 5/0) and lt. olive brown (2.5Y 5/4) ↓ Dark yellowish brown (10YR 4/4)	F ↓	N ↓	M ↓ S	WK ↓ N	FS ↓ pebble	N ↓	Fe concretions ↓
40	20													

B.4 REFERENCES

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