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Phase I Source Investigation, Heckathorn Superfund Site, Richmond, California

N.P. Kohn
N.R. Evans

December 2002

Prepared for the U.S. Department of Energy
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PHASE I SOURCE INVESTIGATION, HECKATHORN SUPERFUND SITE, RICHMOND, CALIFORNIA

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Sequim, Washington

December 2002

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Pacific Northwest National Laboratory
Richland, Washington

SUMMARY

The purpose of the present study is to identify the sources of dichlorodiphenyl trichloroethane (DDT) that have re-contaminated the sediment in Lauritzen Channel since remedial dredging in 1996 and 1997. The study reported here is Phase I of a phased approach to source investigation, in which the most likely DDT sources--outfall pipes and undredged channel sediment or unexcavated bank sediment--were investigated. Where possible, outfall pipes found during the Phase I survey were sampled for sediment and water. If present, sediment was collected directly from inside the mouth of the pipe; otherwise, a special sampler designed to trap particles from outfall discharge water was attached to the outfall pipe. To determine whether water flowing from outfall pipes carried significant quantities of pesticides into the channel, passive water samplers were placed in the end of the known outfall pipes. Passive water samplers and outfall sediment were analyzed for DDT and other pesticides of concern. Most of the identified outfalls are not considered a significant source of the DDT sediment contamination in Lauritzen Channel, but two of the outfalls bear further investigation: a concrete outfall found near Transect -8.5 and the 8-in. metal pipe outfall protruding from the retaining wall near Transect -28. The concrete pipe was discovered discharging a small volume of DDT-contaminated water during the March sampling, and may indicate a groundwater connection between upland bank soils and the channel. The 8-in. pipe could not be ruled out as a source: despite relatively low sediment concentrations, the passive sampler deployed there indicated exposure to high concentrations of DDT.

The undredged sediment under the Levin Pier and the northeast bank of Lauritzen Channel were evaluated in an underwater reconnaissance survey to document the present type, slope, and thickness of sediment under the Levin pier, and to identify potential sediment sampling locations. Thirty eight sediment samples were collected at locations of interest, both underwater in soft channel sediment and from intertidal or terrestrial soils on the embankment, and analyzed for DDT and other pesticides of concern. Bank soil samples collected from the channel bank near the north end of the Levin Pier contained higher concentrations of DDT than those previously found in channel sediments. The soft core collected at Transect +2.5, beneath the north end of the Levin Pier, had the highest DDT concentration found yet in Lauritzen Channel sediment (23,190 ppm), more than 100 times higher than the highest concentrations found in surface sediment during the 1999 Sediment Investigation. Although the volume of soft sediment along the east bank was estimated to be relatively small, sediment core samples provide evidence for redistribution of undredged sediment from under the pier as a source of DDT contamination to the rest of Lauritzen Channel. However, it is the continuing contribution of upland bank material by erosion and possible groundwater leaching that warrants further investigation at the Heckathorn site.

ACKNOWLEDGMENTS

The Phase I Source Investigation could not have been completed without the Battelle Marine Sciences Laboratory (MSL) Dive Team, specifically Dive Team Captain John Southard and divers Greg Williams and Susan Sargeant. We also acknowledge the assistance and support of Andy Lincoff of EPA Region IX Laboratory, Remedial Project Manager Carmen White of EPA Region IX, and Elizabeth Vonckx, Tyler Gilmore, Deborah Coffey, Blythe Barbo, and Lee Miller of Battelle.

CONTENTS

TABLES

FIGURES

1.0 INTRODUCTION

1.1 SITE BACKGROUND

The Heckathorn Superfund Site in Richmond, California, encompasses the property of the former United Heckathorn pesticide packaging plant and the adjacent waterway, Lauritzen Channel (Figure 1-1). The site was used from 1945 to 1966 by several operators to produce various agricultural chemicals, including dichlorodiphenyl trichloroethane (DDT), its breakdown products dichlorodiphenyl dichloroethane (DDD) and dichlorodiphenyl dichloroethylene (DDE), dieldrin, and other pesticides. The site was placed on the National Priorities List of Superfund sites in 1990, which resulted in the removal of pesticide-contaminated soil from the upland portion of the site and dredging the marine portion of the site.

Remediation of the channel by dredging, dewatering, and offsite disposal of contaminated sediment took place between July 1996 and March 1997. Sampling during the dredging operation indicated that the significant mass of contamination was removed. However, subsequent sampling, particularly during the 2-year post-remedial sampling of marine water and biota (1998-1999), indicated pesticide contamination significantly above the remediation goals in the Record of Decision and suggested that there was a potential re-contamination problem in the channel. The post-remediation marine monitoring and associated studies, described in Section 1.2, indicated that the contamination in the channel continues to pose a significant risk to biota and human health.

1.2 PREVIOUS INVESTIGATIONS

Post-remedial monitoring data demonstrated that the pesticide DDT[1] was less bioavailable to marine biota 2 to 3 years after remediation than it was in the first 6 to 10 months after remediation (Figure 1-2) (Antrim and Kohn, 2000a, 2000b; Kohn and Kropp 2001a). However, DDT was detected in the tens of parts-per-million (ppm) range in sediment samples collected from Lauritzen Channel in October and November 1998. Sediment DDT concentrations greater than 590 µg/kg were first measured in October 1998 and reported in Anderson et al. (2000). DDT in sediment was confirmed by additional measurements in November 1998 (Antrim and Kohn, 2000b), and was additionally verified in the 1999 Sediment Investigation (Kohn and Gilmore 2001) (Figures 1-2 and 1-3). Furthermore, an increase in bioavailability of DDT to mussels in Lauritzen Channel was observed in 2001, the fourth year of post-remediation monitoring (Kohn and Kropp 2001b) (Figure 1-2).

1 Throughout this document, "DDT " is generally intended to mean DDT and its breakdown products. "Total DDT" is used to indicate concentrations that are the sum of detected DDT, DDD, and DDE compounds.

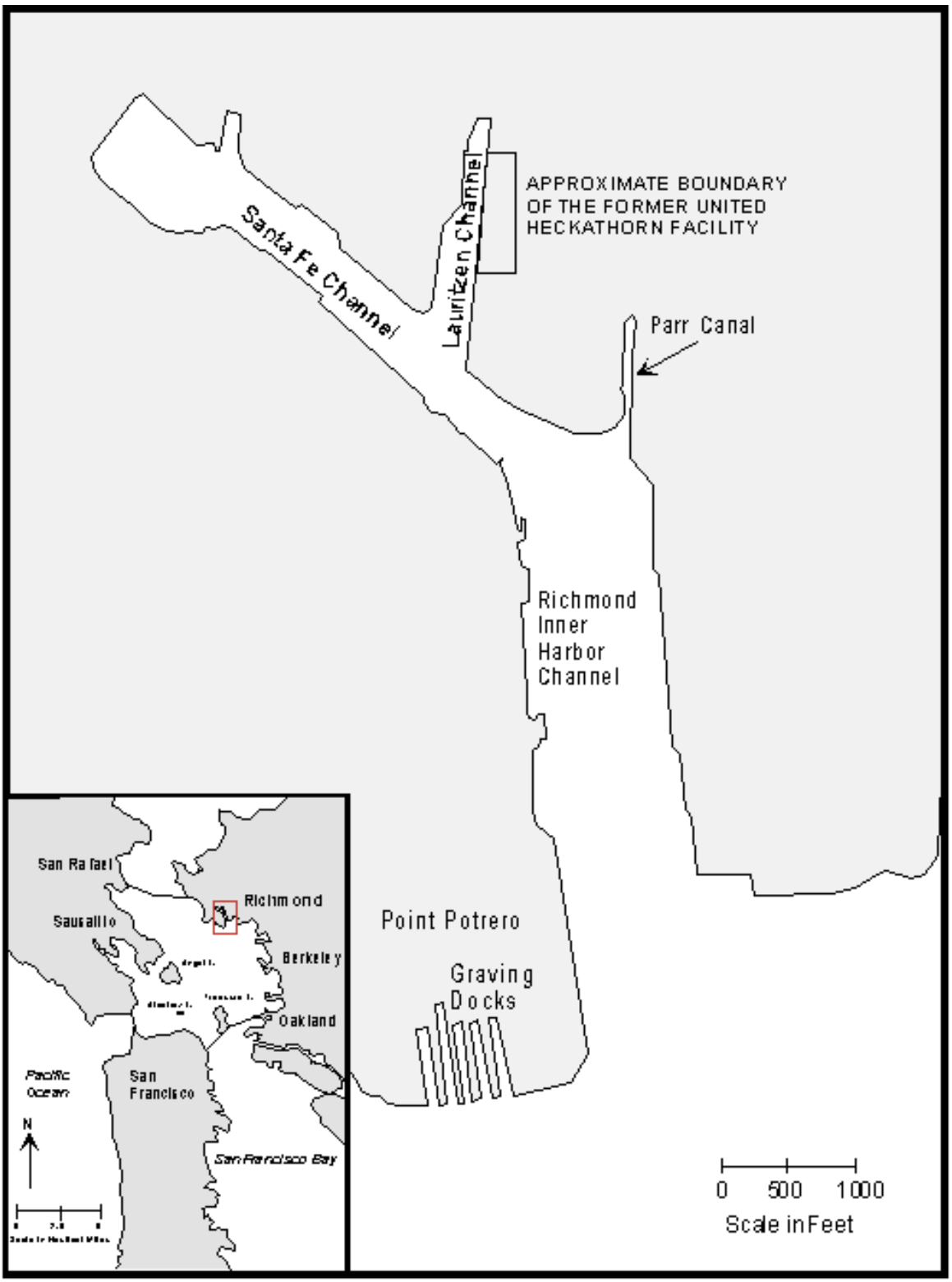


Figure 1-1. Location of the Heckathorn Superfund Site, Richmond, California

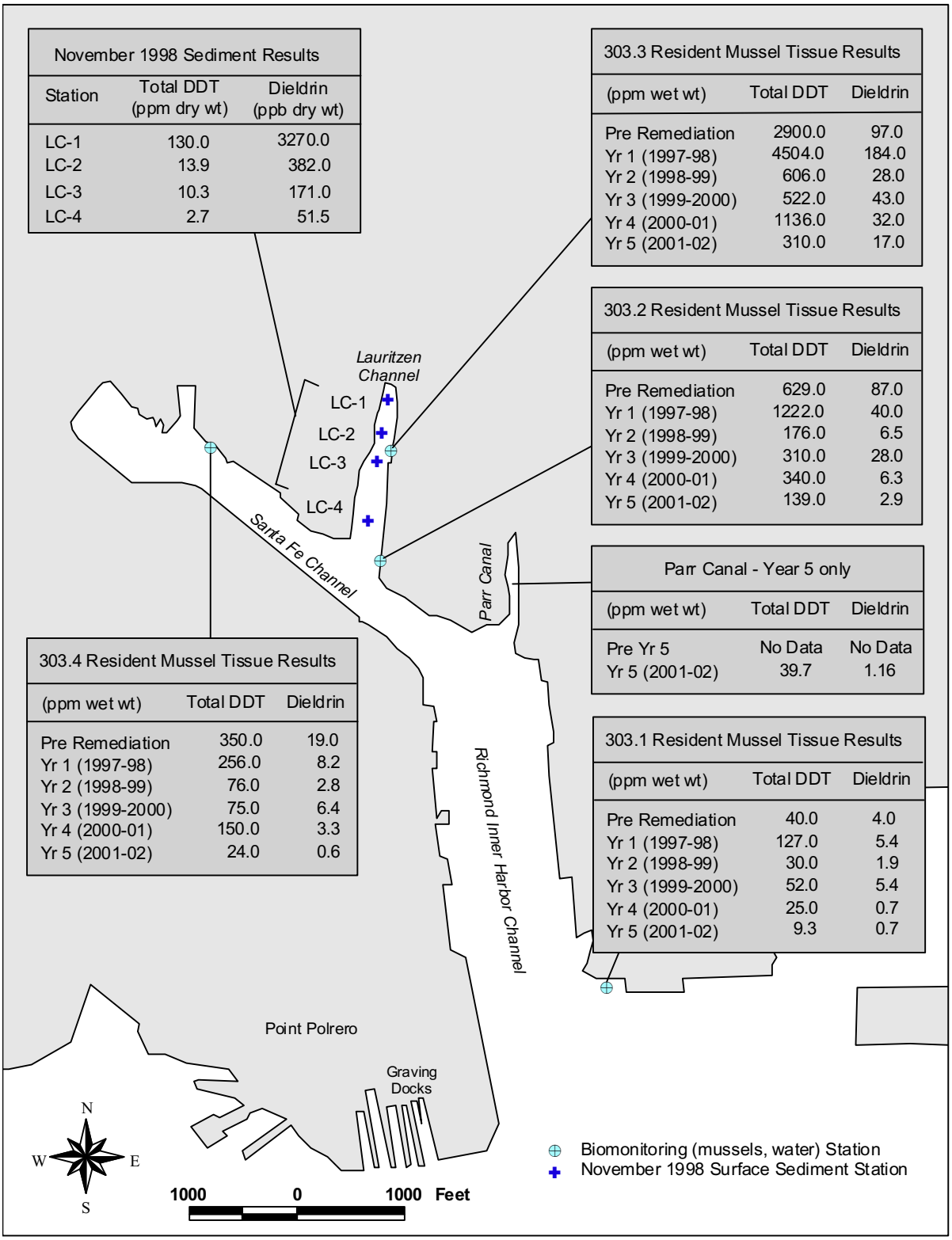


Figure 1-2. Sample Locations and Results of Post-Remedial Monitoring Near the Heckathorn Site

The 1999 Sediment Investigation (Kohn and Gilmore 2001) was undertaken in July 1999 to supplement the post-remediation monitoring program by determining the extent and identifying potential sources of observed pesticide contamination. That investigation revealed that DDT concentrations exceeded the remedial goal of 590 µg/kg dry weight in nearly all the soft surface sediment in Lauritzen Channel (Figure 1-3). The source of contaminated sediment could not be confirmed; no clear correlation was observed between high DDT concentrations and sediment remaining between the pilings, as was originally suspected. Nor was there a distinct pattern that would associate the high DDT concentrations in sediment with the locations of outfalls, although some of the contamination retained by the creosote-treated wood appeared to be highest close to the known outfalls. In addition, sediment movement in the channel could mask a direct association. Five new outfalls discharging to Lauritzen Channel were installed during construction of the upland cap from 1998 to 1999 (the last major remedial action). During routine stormwater and sludge monitoring in late 2000, no pesticides were detected in stormwater and approximately 2.4 ppm total DDT (DDT+DDD+DDE) were detected in sludge from upland stormwater interceptors (LRTC 2001).

The purpose of the present study is to identify the source(s) of DDT that have re-contaminated the sediments in Lauritzen Channel after dredging of channel sediments as part of remedial actions performed in 1996 and 1997. It is important to determine the source in order to prevent further contamination and develop an approach for remediating the channel in a manner that will provide long-term protection of human health and the environment. The study reported here is Phase I of a multi-phased approach to the source investigation, in which the most likely sources were investigated. The most likely sources identified are as follows:

- Contamination sloughing in from undredged areas, such as the side banks under the Levin pier, primarily on the east side of Lauritzen Channel
- Contamination entering the channel from the outfall pipes in the channel.

The specific objectives of Phase I were as follows:

- Evaluate pesticide concentrations associated with discharge from outfalls
- Identify any additional outfalls under the Levin pier
- Identify type, quantity, and distribution of sediment under the Levin pier
- Quantify pesticide concentrations in sediment from under the pier
- Evaluate sediment structure and slope stability under the Levin pier.

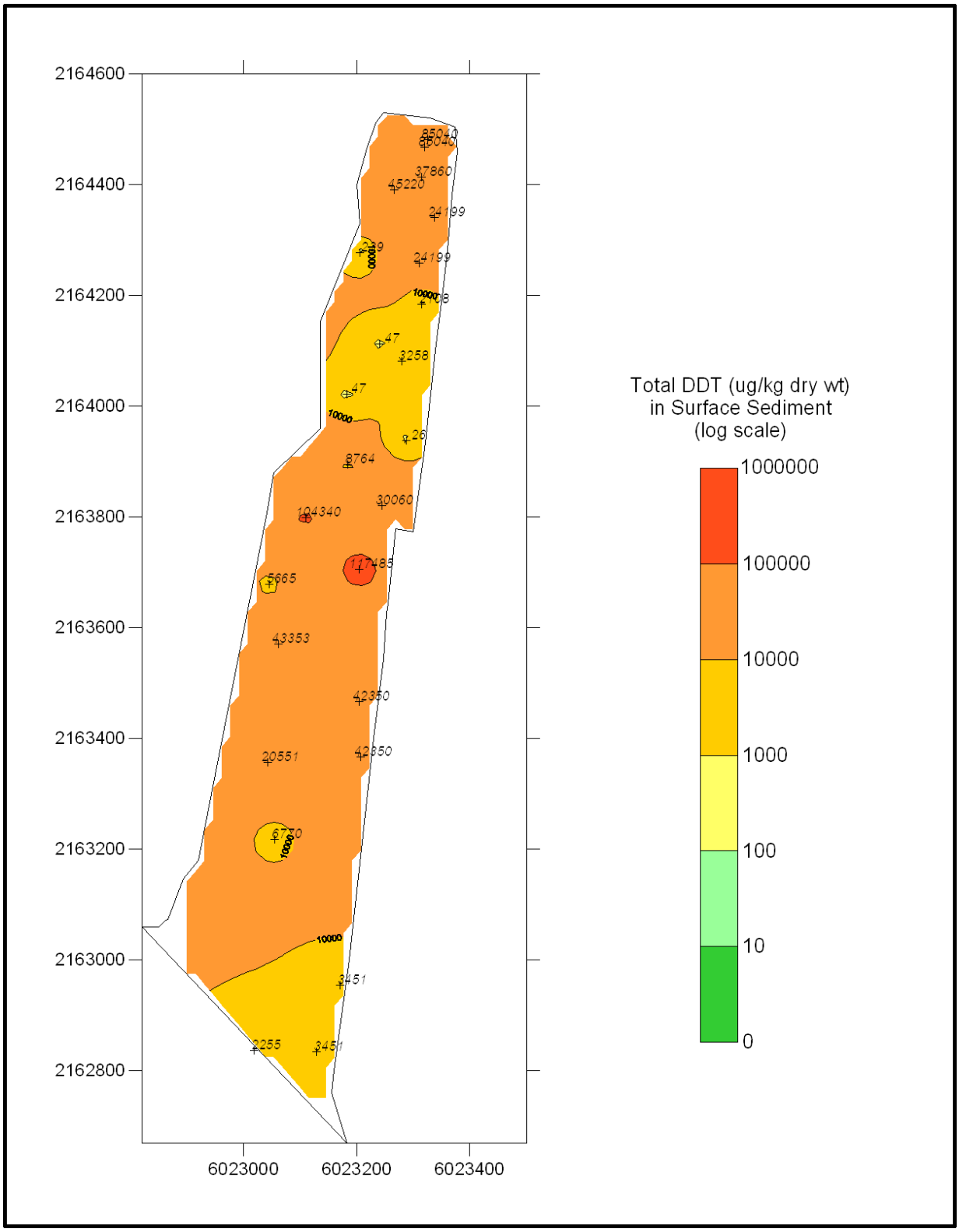


Figure 1-3. Total DDT in Lauritzen Channel Surface Sediment (mostly Younger Bay Mud), 1999 Sediment Investigation

Subsequent investigations will be based on the results of this first phase. If Phase I is able to identify the sources as the upland areas and/or the east side bank sediment, Phase II will be designed to determine the extent and fate of the contamination.

The materials and methods for the Phase I Source Investigation are described in Section 2 of this report. The results of field activities and sample analyses are provided in Section 3. Survey data are analyzed and discussed in Section 4, with recommendations for follow-up studies and monitoring. References are provided in Section 5.

2.0 METHODS

2.1 OUTFALL SAMPLING

Prior to the Phase I Source Investigation field survey, 12 outfalls were identified in the Lauritzen channel. Five of these outfalls are part of the upland cap. The upland cap consists of graded paving, curbing, and a stormwater collection system to control surface water runoff from the upland part of the site, which is currently the Levin Richmond Terminal. The cap prevents direct runoff to Lauritzen Channel, and directs stormwater through a series of drain inlets and piping to interceptors that retain the water and collect settled particles and sludge. Each interceptor has an outfall discharging to Lauritzen Channel, and has been sampled under an inspection and monitoring program for the cap. The upland cap monitoring has shown low levels (<1 ppm) of DDT in interceptor sludge; therefore, the cap outfalls were not considered significant sources of DDT recontamination and were not sampled during Phase I. The seven other outfalls in the channel include five previously identified pipes and two outfalls identified on the drainage map provided by the City of Richmond. Where possible, the previously identified pipes and any undocumented pipes found during the Phase I survey were sampled for sediment and water as follows.

2.1.1 Outfall Sediment Sampling

Sediment, if present, was collected directly from inside the mouth of the pipe. If there was little or no sediment in the pipe, a sediment sampler designed to trap particles from outfall discharge water was attached to the outfall pipe. The samplers, called "Y-traps," were fabricated from PVC and polycarbonate irrigation fittings and secured to the lower edge of the outfall pipe by a specially fabricated metal bracket (Figure 2-1). The bracket was designed to direct the flow containing sediment into the Y-trap, while not interfering with discharge in the upper part of the outfall. The Y-trap was designed to trap flow containing sediment in the lower leg of the Y, which was fitted with a stainless steel mesh filter lined with very fine mesh Nytex screen. Excess water flow escaped through upper leg of Y, which was fitted with a one-way valve to prevent water from coming back up the pipe. After 4 weeks of deployment, sediment was scraped from the mesh screen using a solvent-rinsed stainless steel spatula (Figure 2-1).

Clockwise from upper left: Y-trap prepared in laboratory, Y-trap deployed in municipal outfall at head of Lauritzen Channel, Y-trap deployed in 8-in. pipe in northeast Lauritzen Channel, collecting sediment from strainer removed from Y-trap from 8-in. pipe.

Figure 2-1. Outfall Sediment Collection Traps

2.1.2 Outfall Water Sampling

To determine whether water flowing from outfall pipes carried significant quantities of pesticides into the channel, passive water samplers were placed in the end of the known outfall pipes discharging to Lauritzen Channel. The samplers were deployed over a 4-week period to collect a time-integrated sample during the expected rainy season (February 5 through March 6, 2002). Precipitation data from several local monitoring stations are provided in Appendix A of this report. Although the passive samplers collect an integrated sample over time, outfall flow was not continuous and some outfalls are alternately exposed/submerged by tide. Therefore, the passive samplers establish the presence or absence of pesticides in the outfall, rather than quantify loading from the outfall, during the deployment period.

Passive samplers were placed in two pipes and at several other locations in Lauritzen Channel on February 6, 2002. Appendix B contains an EPA Field Report describing deployment and retrieval of passive water samplers and direct collection of sediment from in and near outfall pipes. Each passive sampler consisted of a polyethylene film loop that had been solvent-cleaned by soaking 24 h in hexane. The polyethylene film was stored in glass jar capped with a Teflon-lined lid until it was deployed. To deploy a sampler, the polyethylene loop was attached to a length of wire, which was used to attach the sampler either to a weight or to a fixed object such as a piling (see Appendix B, Photo 3). The passive samplers for the outfall pipes were attached to a weight, such as a brick, and set inside the end of the pipe. Samplers were generally deployed where they would be out of sight and out of sunlight or other light.

2.2 LAURITZEN CHANNEL EAST BANK SURVEY

The primary task of the Lauritzen Channel East Bank survey was an underwater reconnaissance survey to document the present type, slope, and thickness of sediment under the Levin pier, identify the location of any additional outfall pipes, and identify potential sediment sampling locations. The second task of the East Bank survey was to collect sediment samples at locations of interest, both underwater in soft channel sediment and from intertidal or terrestrial soils on the embankment. Methods are described in detail in the Source Investigation Sampling and Analysis Plan (Battelle 2002), but are summarized briefly below.

2.2.1 Underwater Survey

The underwater survey of the east side of Lauritzen Channel was conducted by the Battelle Marine Sciences Laboratory (MSL) Dive Team on March 11-13, 2002. Divers were equipped with two-way radio units in full-face masks to maintain communication with each other and the field team leader on the vessel. The EPA Region IX Laboratory provided the vessel and operator used for the Lauritzen Channel East Bank survey.

Prior to any diving on site, a transect naming system and navigational baseline were established. Transect naming followed the numbers assigned to the rows of pilings supporting the Levin pier, each of which is assigned a whole number starting with +1 at the north end of the pier. The rows of pilings are approximately 15 ft apart and every so often are clearly numbered on a placard on the pier face. This numbering system was established by Levin during pier maintenance and exists independently of the Source Investigation. North of the Levin Pier, the piling rows continue even though there is no existing pier deck. For the East Bank survey, the piling rows north of the pier were assigned negative numbers starting with –1 for the first row, about 15 ft north of Transect +1. Lauritzen Channel East Bank survey transects were then numbered based on the pier numbering system, using half numbers because the underwater survey occurred in the gaps between piling rows (Figure 2-2). A navigational baseline was established by recording the coordinates of piling row 67 (south end of Levin Pier) and every fourth gap between pilings to the north, using a handheld global positioning system GPS unit (Garmin 3+) at the pier face. Several visual reference points were also surveyed, such as the boundary between Levin Berths B and C. The distance between transects was also recorded and used to continue the regular transect spacing north of the Levin Pier. North of the Levin Pier where there was no pier deck, the baseline coordinates were recorded from the edge of the shoreline or sheetpile wall. The baseline coordinates were entered into ArcView GIS software and overlaid on a georeferenced aerial photograph. Because the handheld GPS was not differentially corrected and its accuracy is variable, transect coordinates were corrected in ArcView GIS to show the regular spacing and relationship to the pier and northeast Lauritzen shoreline (Figure 2-2).

Underwater survey data were collected at every fourth transect except in the middle section of the east bank at the north end of the Levin Pier. Between Transects +11.5 and –4.5, every third transect was surveyed to increase the density in the areas of highest suspected contamination. Data were collected at 3-m intervals on the centerline of the 5-m (~15-ft) gap between pilings by a team of divers. The first diver staked the end of a survey tape in the bottom at the pier face and ran it along the bottom and onto shore. The first diver occasionally made qualitative observations about the slope or presence of debris or obstacles, but the second diver collected the quantitative information. Because visibility was extremely poor, all data were relayed via radio to the field team leader, who recorded the data in the field log book. The second diver descended to the 0-m end of the survey tape. At 0-m and each 3-m interval along the tape, the second diver relayed the water depth (measured using calibrated pressure gauges on a dive computer), surface sediment type and characteristics, and the depth of soft penetrable sediment (measured using a length of PVC pipe marked in cm).

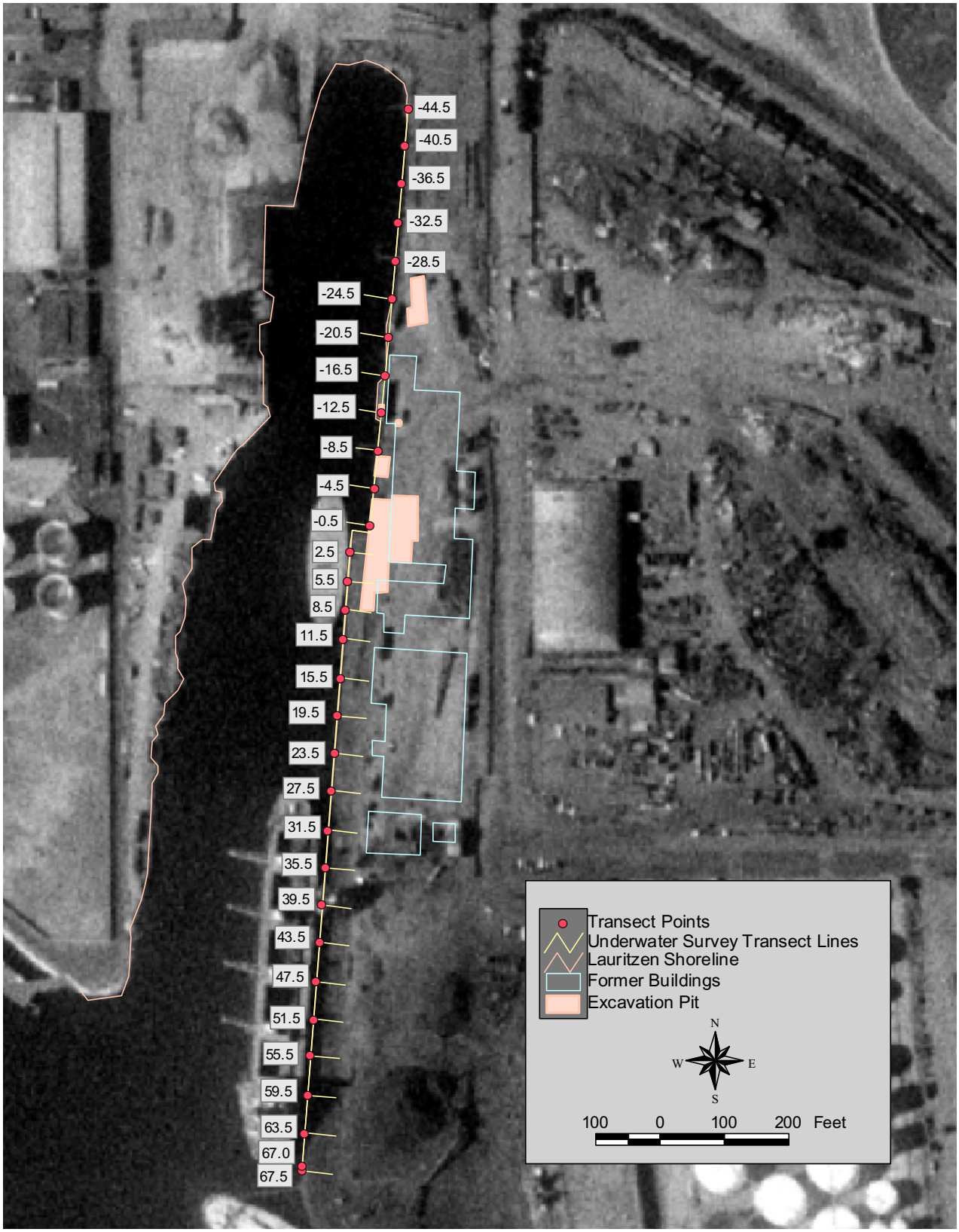


Figure 2-2. Lauritzen Channel East Bank Survey Transects

The second diver also described and provided the location (distance along the survey tape) of any unusual features such as distinct slope changes, debris, or live organisms. The time of each depth measurement was recorded so that water depths could be corrected for the tide height to mean lower low water (MLLW). The straight horizontal distance of each transect, from the 0-m mark (pier face line) to vertical or sheetpile wall on shore, was measured with a laser range-finder from the support vessel. Figure 2-3 shows an example of a survey transect profile with measurement parameters shown in red.

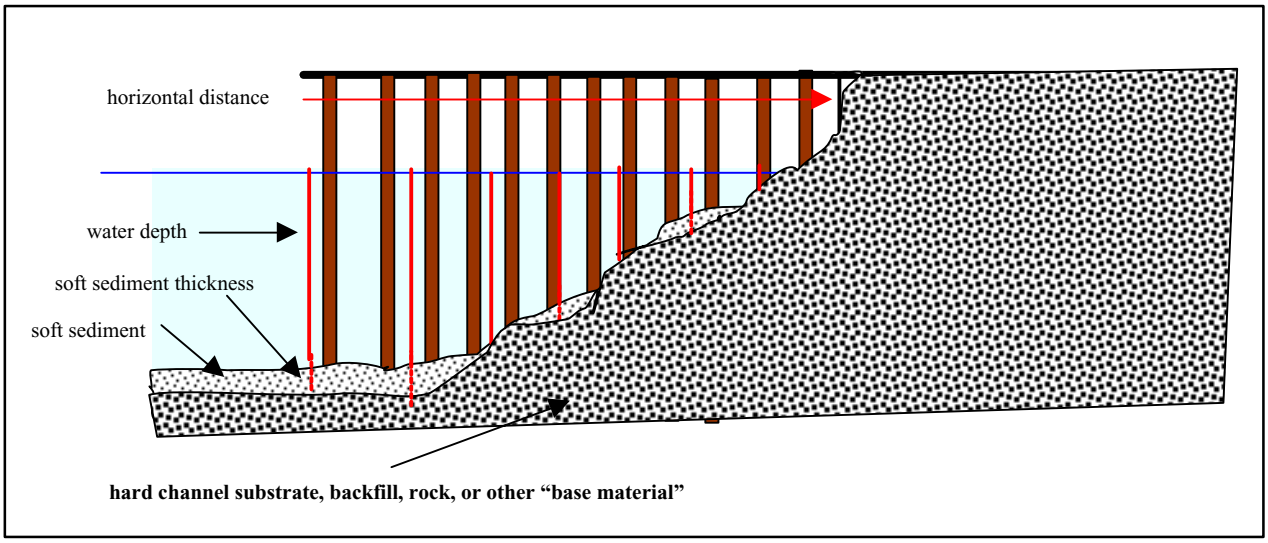


Figure 2-3. Conceptual Profile View of Underwater Survey Transect Beneath Levin Pier

2.2.2 Sediment and Bank Soil Sample Collection

Seventeen sediment and soil sampling locations were selected by the EPA Remedial Project Manager (RPM) to target suspected source areas based on the locations of former buildings, the extent of prior excavations, thickness of soft sediment under the pier (from the underwater survey), and previous sediment data. Sediment sampling locations for soft sediment cores (sample ID with C1 suffix) and embankment samples (sample ID with B suffix) are shown in Figure 2-4. Divers collected nine soft sediment samples using small pieces of clean, disposable acetate tubing approximately 3 cm in diameter as a push core. The diver capped both ends under water before bringing the sample to the surface (Figure 2-5a). Once the sample was on the boat, the depth of core recovered was measured, and the sediment was placed in a labeled, pre-cleaned glass sample container with Teflon-lined lid. Core sampling points were georeferenced to a GPS-surveyed baseline along the top outermost edge of the pier, as the GPS system does not function beneath the pier. The field team derived coordinates of each sampling point on top of the pier, using the GPS at the point that was the distance and direction from the baseline recorded during sampling.

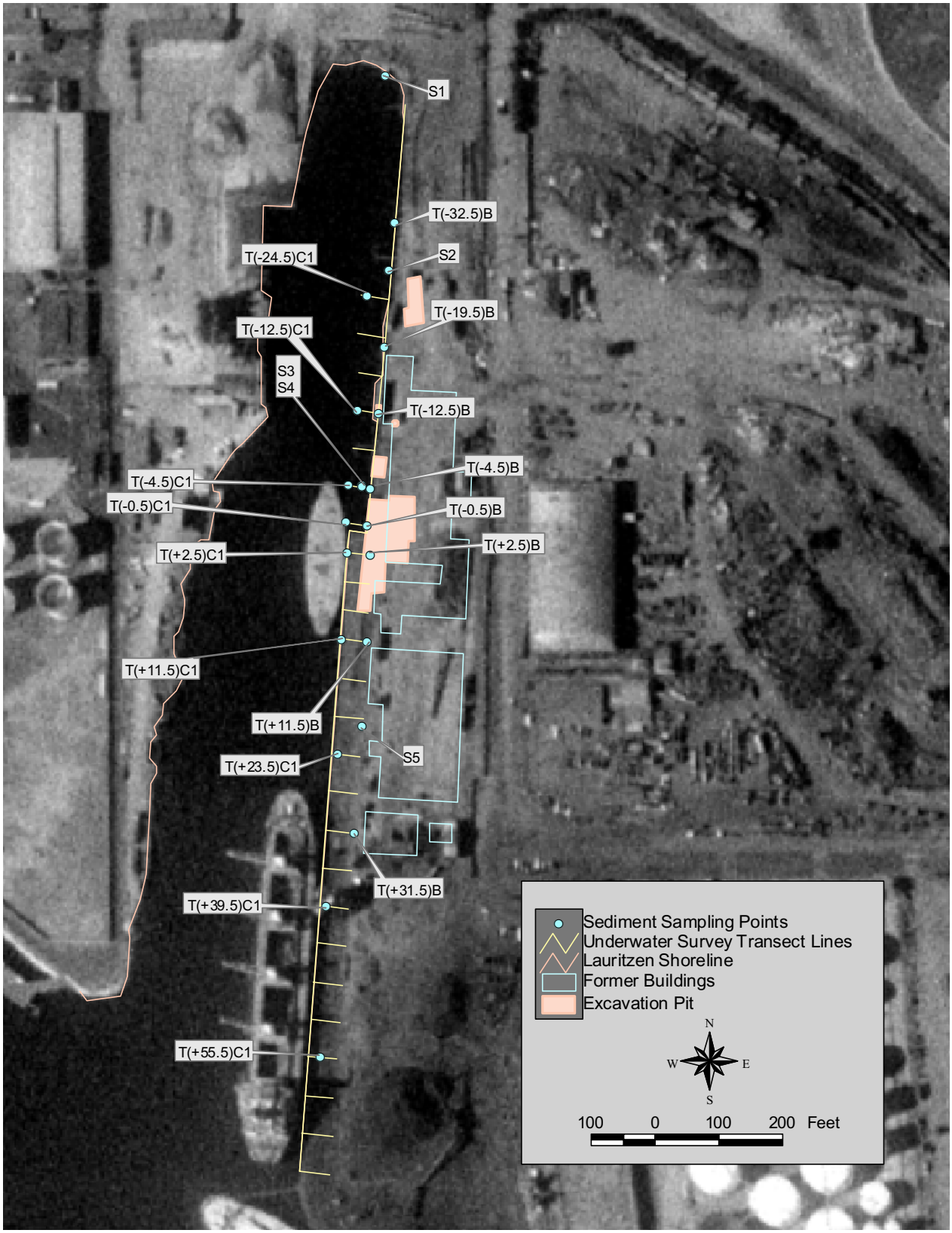


Figure 2-4. Lauritzen Channel East Bank Survey Sediment Sampling Locations, March 2002

(a)

(b)

Figure 2-5. Lauritzen Channel (a) Soft Core and (b) Terrestrial Bank Soil Collection

Typical bank sediment collection from beneath Levin Pier is shown in Figure 2-5b. Bank sediment was collected where material appeared to be terrestrial, but with a direct pathway to the channel. Where the substrate was primarily large rocks or cobbles, the looser sand, silt, and gravel was collected from between them. Most bank soil samples were collected using a new, sterile, disposable scoop for each sample. The exception was T(-19.5)B, where softer bank material could be collected by pushing an acetate core tube horizontally into the clay above the waterline. As with the cores, sampling points beneath the Levin pier were obtained by placing the GPS unit on the pier the distance and direction from the baseline that the sample was collected.

Based on the preliminary results obtained from the 17 samples collected in March, EPA collected 21 additional samples, mostly soft sediment cores, in an attempt to bound the area of highest sediment contamination. EPA's sampling was conducted in July, 2002, at the stations shown in Figure 2-6. EPA core samples were collected using a push-coring device deployed from a small boat, rather than by divers as described above. EPA's field report in Appendix B details the sampling method and equipment.

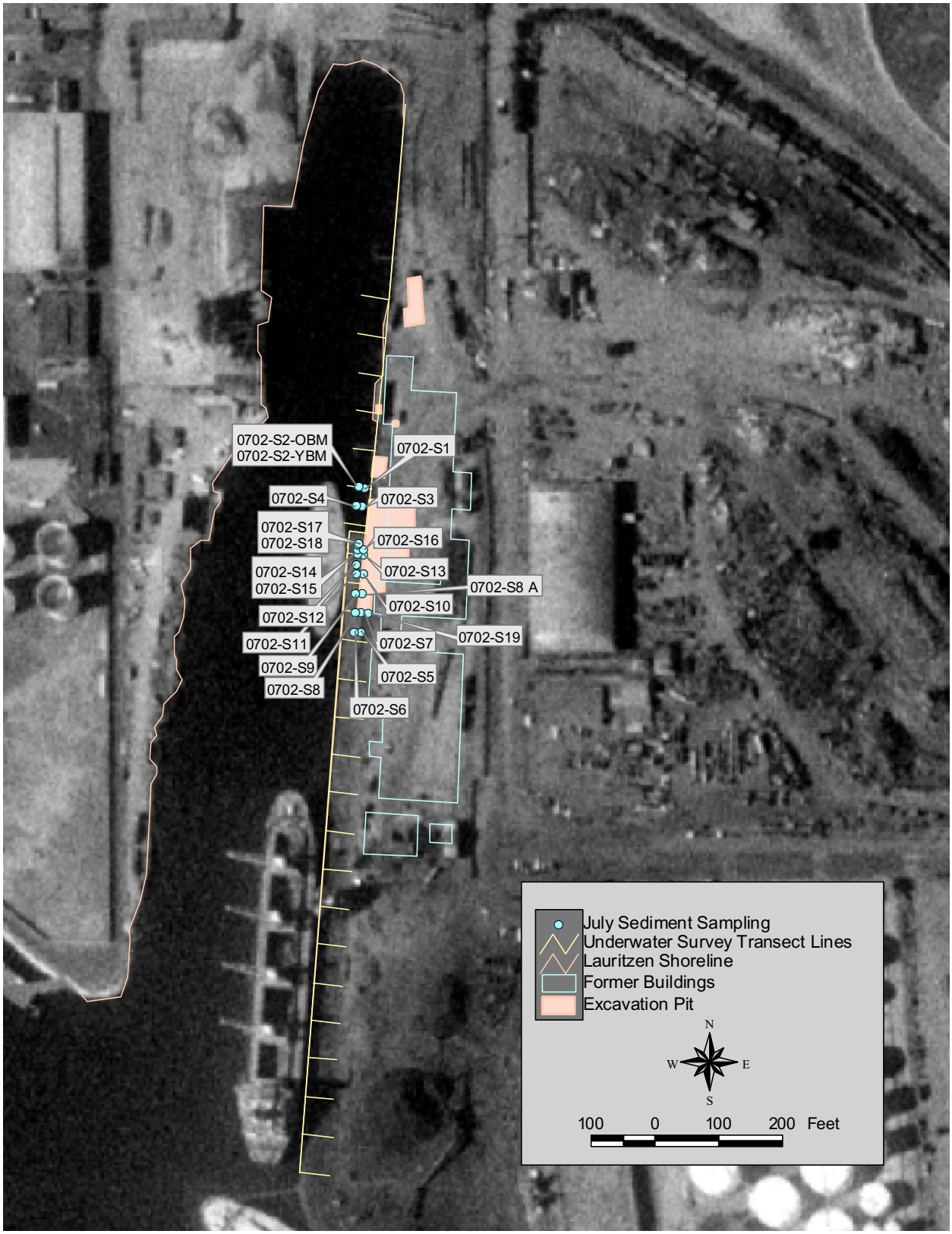


Figure 2-6. Supplemental EPA Sediment Sampling Locations, July 2002

2.2.3 Lauritzen Channel East Bank Survey Data Analysis

The data collected during the underwater survey and sediment sample collection tasks of the Lauritzen Channel East Bank survey were entered into Microsoft Excel spreadsheets from which tables could be prepared for presentation and for importing into ArcView GIS. ArcView GIS (version 3.2) and Surfer (version 8.0) software packages were used to present the data clearly in visual form. Plots of sample locations and sample concentrations were created in ArcView. Plots of bathymetry and sediment thickness in the area of the underwater survey were prepared in Surfer, using data exported from ArcView as follows. Sediment sampling points were plotted in ArcView using the distance along each transect from a known starting point. At each point, sediment thickness was entered as an attribute of that point. The plotted points were converted to a universal transverse mercator projection using ArcView to obtain x and y coordinate values in meters. The sampling points were then printed to a data table containing the calculated x and y coordinates and sediment thickness for each point. This data table was interpolated using Surfer's triangulation with linear interpolation gridding function (using default settings for grid parameters and grid spacing), which essentially connects the dots between each sampled point, estimating the change in sediment thickness between those points to establish a regularly-spaced array of data. The resulting three-dimensional surface was then used to calculate the volume of sediment, using Surfer's grid volume calculation capability.

One minor source of uncertainty is that the actual horizontal distance between data points along each transect is not known. The divers reported data every 3 m along an uneven, sloping bottom surface. The straight-line horizontal distance used for plotting data and calculating the volume was estimated from the actual diver-reported measurements by using the Pythagorean Theorem and a series of right triangles from one point to the next. The diver-reported distance was used as the hypotenuse, and the change in water depth from one diver-reported point to the next as the vertical change. Rapid changes in slope or irregularities/obstructions between reported points may cause some uncertainty in the horizontal distance calculations.

2.3 ANALYTICAL CHEMISTRY

Outfall, sediment core, and bank samples were analyzed for DDT and other chlorinated pesticides by the EPA Region IX Field Laboratory in Richmond, California. Passive water samplers and one bulk water sample were analyzed for DDT by Battelle MSL, Sequim, Washington. Both laboratories followed EPA Method 8081b for measuring organochlorine pesticides by gas chromatography (EPA 1998). Samples were solvent extracted and purified using a high-performance liquid chromatography (HPLC) size-exclusion technique. Analysis was by capillary gas chromatography with electron capture detection

(GC/ECD). Quality control (QC) samples included a method blank, matrix spike (MS), matrix spike duplicate (MSD), and sample duplicate. The specific pesticides of interest at the Heckathorn site are dieldrin and the 2,4'- and 4,4'- isomers of DDT, DDD, and DDE. Total DDT was reported as the sum of detected isomer concentrations. EPA Region IX also measured other chlorinated pesticides on the Method 8081b list in the outfall, bank soil, and sediment core samples.

3.0 RESULTS

The Phase I Source Investigation field program was conducted in February and March 2002. On February 6, 2002, EPA investigated the identified outfall pipes and identified one new pipe under the Levin Pier. EPA also collected sediment from in and near outfall pipes and deployed passive water samplers and Y-traps in accessible outfalls that appeared to have some active flow. Passive water samplers were also deployed at several points of interest away from outfalls in Lauritzen Channel, and at the four annual post-remediation monitoring sites. EPA's field summary report is provided in Appendix B of this report.

3.1 OUTFALL SAMPLING

A summary of outfalls located and samples collected is provided in Table 3.1; outfall locations are shown in Figure 3-1. Photodocumentation is provided in Figure 3-2 for those outfall pipes that were possible to photograph. Seven outfalls were identified prior to the field survey. Upon actual field reconnaissance of the expected locations, three were not found and a valve closed one off. Four previously unidentified pipes were found during the field survey. Three pipes were located under the Levin Pier at Transects +20, +31.5, and +59.5. The other was a concrete pipe in the intertidal zone near Transect –8.5, approximately 40 m north of the Levin Pier. The concrete pipe was difficult to see, because the end was broken and covered with algae and blended in with the bank material, although it was almost directly below the landing of the ramp leading down to the floating dock just north of the Levin Pier. The EPA RPM discovered the concrete pipe during the Phase I Lauritzen East Bank survey in March. This outfall was not identified in time to deploy a Y-trap or passive sampler at the time of the initial outfall sampling, but a bulk water sample was collected from it on March 11, 2002.

3.1.1 Outfall Sediment Chemistry Results

Pesticide concentrations in sediment collected in and near outfall pipes in Lauritzen Channel are provided in Table 3.2. Complete analytical chemistry results, including quality control sample results, are provided in Appendix C. Although DDT and dieldrin were detected in the majority of outfall sediment samples, total DDT concentrations in all except S-2 were near or below 1 ppm dry weight (Figure 3-1). The total DDT concentration in S-2, collected from inside the 8-in. outfall shown in Figure 3-2b, was 8.7 ppm dry weight. DDT was even lower in the small amount of sediment collected from the Y-trap deployed in the 8-in. pipe (Table 3.2). The Y-TRAP-8 results are reported on a wet weight basis, but conservatively assuming 60% to 70% moisture, the estimated dry weight concentrations would be about three times the wet weight concentrations, which is still lower than those seen in S-2.

Table 3.1. Outfall Sampling Information, Heckathorn Phase I Source Investigation

Description	Comments	GIS Coordinates (dd.dddddddd NAD83)		Sample Collection		
		Latitude (N)	Longitude (W)	Pipe Sediment	Vicinity Sediment	Water
Documented Pipes						
Large concrete municipal outfall at north end of Lauritzen Channel (approx Transect -47)	Some water flowing at February 6 Y-trap and passive sampler deployment. Figure 3-2 (a).	37.924607724	-122.366521242	Yes S-1, Y-trap-48"	No	Yes (passive sampler)
8-in. metal outfall through retaining wall about 2 ft above sediment (approx Transect -27.5)	Some water dripping at February 6 Y-trap and passive sampler deployment (pipe is submerged at high tide). Figure 3-2 (b).	37.923765490	-122.366511586	Yes S-2, Y-trap-8"	No	Yes (passive sampler)
5.5-in. metal pipe through retaining wall about 5 ft above present sediment surface, same location as 8-in. pipe above (approx Transect -27.5)	No sediment in pipe, no water flow, none of the Y-trap brackets were small enough to attach; not sampled. Figure 3-2 (b).	37.923765490	-122.366511586	No	No	No
L-shaped pipe (approx Transect -24.5)	Valved closed; not sampled. Figure 3-2 (c).	37.916781667	-122.366668333	No	No	No
Screened pipe end in riprap near north end of sheetpile wall, east bank of Lauritzen Channel	Not found during field survey	37.916795556	-122.350273889	No	No	No
Pipe discharging to west side of channel, identified on City of Richmond drainage map.	Not found during field survey	NA	NA	No	No	No
21-in. pipe discharging beneath Levin Pier, identified on City of Richmond drainage map.	Pipe this size not found at expected location during field survey, but several smaller previously undocumented pipes were found beneath pier.	NA	NA	No	No	No
Previously Undocumented Pipes						
Concrete pipe at bottom of riprap (approx Transect -8.5)	Some flow from this pipe in March; pipe is difficult to see as it blends in with cobbles and rip rap. Figure 3-2 (d).	37.916772500	-122.350276944	No	No (S-3, S-4 collected 18 m south)	Yes (bulk water)
Corroded metal pipe identified during Feb. 6 deployment, under Levin Pier at Transect +20.	Appears valved off, end very corroded. Figure 3-2 (e).	37.921865947	-122.366915980	No	Yes, S-5	No
6-in. diameter pipe, under Levin Pier at Transect +31.5	Appears to discharge occasionally. Figure 3-2 (f).	37.921339756	-122.366721129	No	Yes T(+31.5)B	No
8-in. diameter pipe, under Levin Pier at Transect +59.5. Coordinates are approximate (estimated distance east from baseline)	Appears valved off, old, unused; not sampled or photographed.	37.916726944	-122.366670278	No	No	No

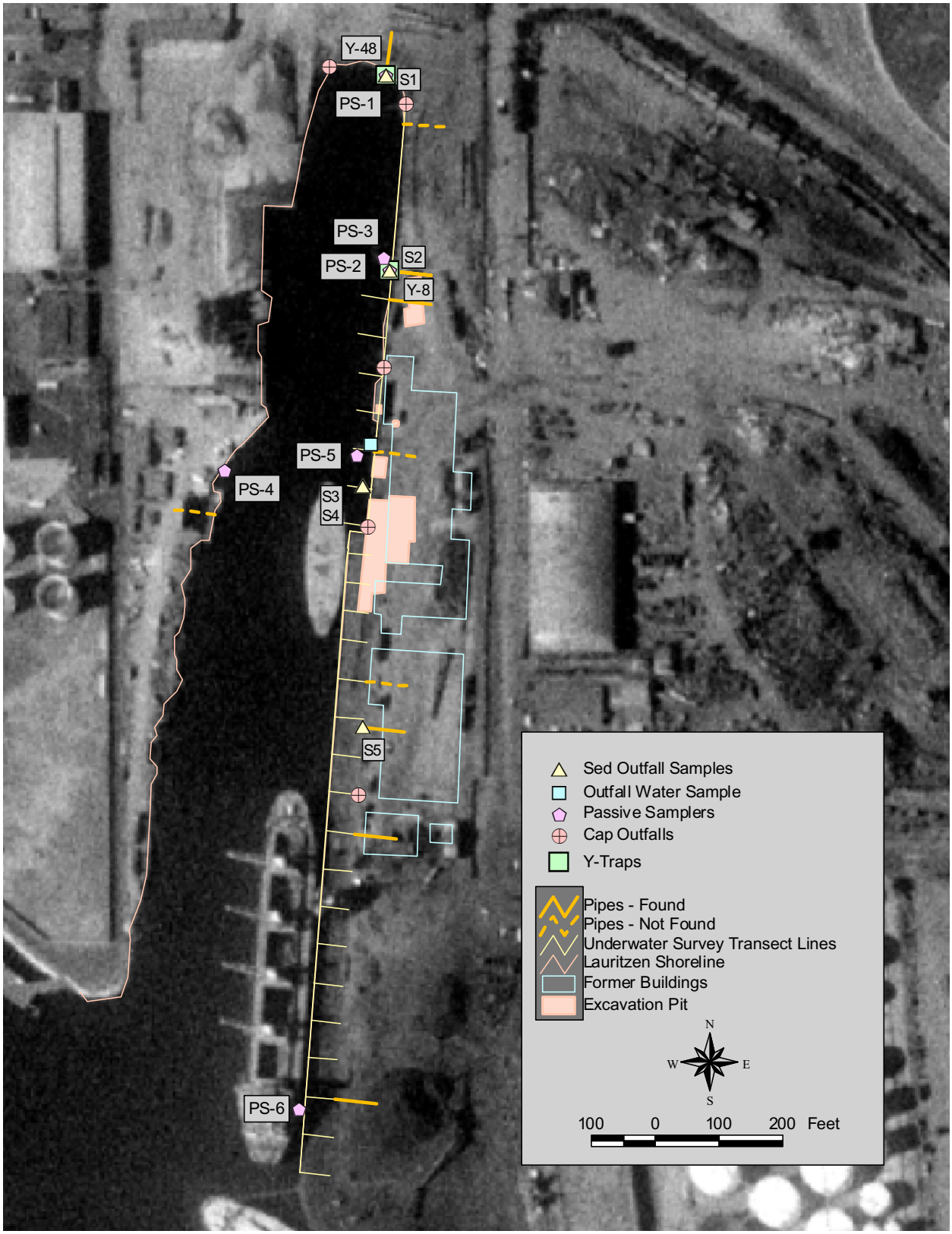
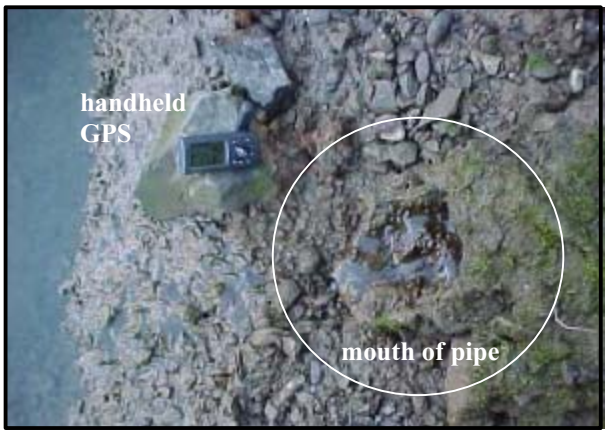


Figure 3-1. Outfall Water and Sediment Sampling Locations

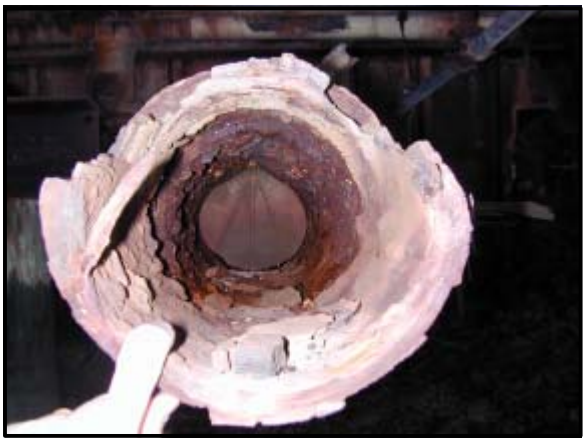
(a) Municipal outfall

(b) 8-in. and 5.5-in pipes through retaining wall (Y-trap is attached to 8-in. pipe, center of photo)

(c) Valved L-shaped pipe near Transect –24.5



(d) Previously undocumented broken concrete pipe with water flowing, near Transect –8.5



(e) Previously undocumented corroded metal pipe under Levin Pier, Transect +20

(f) Previously undocumented pipe under Levin Pier, Transect +31.5

Figure 3-2. Photodocumentation of Outfalls Discharging to Lauritzen Channel

Table 3.2. Chlorinated Pesticide Concentrations in Sediments In or Near Outfalls

	Chlorinated Pesticides in Outfall Sediment Samples (µg/kg dry weight)						
Station ID	Y-TRAP-8"[a]	Y-TRAP-48"	S-1	S-2	S-3	S-4	S-5
DDT and Dieldrin							
2,4'-DDE	20UC[b]	80N	400UC	100CN	20UC	40U	20N
4,4'-DDE	30C	200N	400UC	600C	60C	40U	60
2,4'-DDD	100C	100	400UC	2,200C	80C	40U	20JN
4,4'-DDD	100C	300	300JC	3,300C	120C	40J	40N
2,4'-DDT	70C	80	400UC	500C	340C	30J	80
4,4'-DDT	200C	300N	400UC	2,000C	680C	80	500N
Total DDT[c]	**500**	**1,060**	**300**	**8,700**	**1,280**	**150**	**720**
Dieldrin	**100C**	**40JN**	**400UC**	**2,800C**	**120CS**	**200**	**70JN**
Other Pesticides							
a-BHC	---[d]	---	---	---	---	---	---
g-BHC	---	---	---	---	---	---	---
b-BHC	---	100N	100CN	---	---	---	40JC
d-BHC	---	---	---	---	---	---	---
Heptachlor	---	---	---	---	---	---	---
Heptachlor epoxide	---	---	---	---	---	---	---
g-Chlordane	7JC	30N	---	5J	8JCS	---	200C
a-Chlordane	---	20N	---	---	5JCN	---	90CN
Aldrin	---	30N	---	20	7JCS	---	40JC
Endrin	600C	---	---	40	---	---	12,000J
Endrin ketone	200C	---	---	---	---	---	5,000C
Endrin aldehyde	10JC	100	---	70N	---	---	200CN
Endosulfan I	---	20JN	---	---	---	---	30JCN
Endosulfan II	---	---	---	---	---	---	80JB
Endosulfan sulfate	---	---	---	20J	---	---	---
Methoxychlor	60JC	---	---	---	---	---	---

(a) Y-TRAP-8" results reported on a wet weight basis because there was not enough material to determine percent moisture.

(b) Qualifiers are defined as follows:
- U Undetected above given value (quantitation limit).
- C Associated surrogate recovery did not meet QC limits.
- N Estimated value: sample matrix interference indicated by >40% difference between concentrations of analyte on two columns; presence of analyte deemed presumptive.
- J Estimated value: below quantitation limit but greater than or equal to ½ the quantitation limit.
- S Associated spike recoveries did not meet QC limits.
- B Estimated value: during calibration verification, difference between columns exceeded QC limit.

(c) Total DDT is sum of detected 2,4'-DDD, 4,4'-DDD, 2,4'-DDE, 4,4'-DDD, 2,4'-DDT, and 4,4'-DDT.

(d) --- None detected.

3.1.2 Outfall Water Chemistry Results

To determine whether pesticides were present in outfall discharge at concentrations high enough to contribute to sediment recontamination in Lauritzen Channel, passive samplers were placed inside accessible pipes (municipal outfall, 8-in. pipe) and in the water column near known or suspected outfalls. Passive samplers were also placed at the routine annual monitoring locations for comparison with bulk water and mussel tissue concentrations (Kohn and Kropp 2002). One bulk water sample was collected from the concrete outfall near Transect –8.5 (Figure 3-1), because this outfall was not identified until after the passive samplers were retrieved. The passive samplers were retrieved on March 6, 2002, in conjunction with annual post-remediation monitoring sample collection. One exception was that the passive sampler in the 8-in. diameter pipe in northeast Lauritzen Channel was retrieved along with the sediment Y-traps on March 14, 2002, during the Phase I Lauritzen East Bank Survey. Pesticide concentrations in passive samplers collected in and near outfall pipes in Lauritzen Channel are provided in Table 3.3. Results for the bulk water sample collected from the newly identified concrete outfall near Transect –8.5 is also provided in this table. Complete analytical chemistry results for water and passive water samplers, including QC sample results, are provided in Appendix D.

All DDT compounds were detected in the single bulk water sample collected from the recently identified concrete outfall (Figure 3-2d). Although the data are qualified (possibly biased high) because the associated surrogate compound was over-recovered (139% recovery of surrogate PCB 198), the concentrations are significant enough that this outfall bears further consideration as a source of DDT to the channel. The total DDT concentration of 4455 ng/L was more than 100 times higher than the 5.5 ng/L to 36.7 ng/L measured in three replicates bulk water samples collected from the Lauritzen Channel/End monitoring station 303.3 the previous week (Kohn and Kropp 2002). This monitoring station has historically exhibited the highest DDT concentrations in water and mussels throughout the 5-year post-remediation monitoring program, and has been a consistent indicator that pesticides remain present and bioavailable in Lauritzen Channel.

Passive samplers PS-3, PS-4, and PS-5, deployed in north central Lauritzen Channel, all showed similar concentrations of total DDT. Similar but slightly lower was PS-1 in the municipal outfall, which was exposed to a mixture of channel water and stormwater runoff. Total DDT in PS-6 at the south end of Lauritzen Channel was about 40% of the concentration of the passive samplers in the north central portion, reflecting the north-south gradient of pesticide concentrations typically observed in the channel.

Table 3.3. DDT and Dieldrin Concentrations in Outfall Water and Passive Samplers Collected In or Near Outfalls

Sample ID	Water Concentration (ng/L)	Passive Water Sampler Concentration (µg/kg polyethylene)					
	Outfall	PS-6 (303.2)[a]	PS-4	PS-5 (303.3)[a]	PS-1	PS-3	PS-2
Location	Concrete Pipe Outfall	Lauritzen South	Manson Pier	Lauritzen North	Municipal Outfall	North Lauritzen (off remnant pier)	8-in. Outfall Pipe
2,4'-DDE	12.4 C[b]D[c]	7.46	31.4 D	35.9 D	37.8 D	40.7 D	992
4,4'-DDE	238 CD	256	358 D	454 D	466 D	412 D	5160
2,4'-DDD	1240 CD	194	743 D	730 D	587 D	792 D	44400
4,4'-DDD	546 CD	558	2440 D	1380 D	1620 D	2080 D	49800
2,4'-DDT	959 CD	188	177 D	685 D	301 D	333 D	8620
4,4'-DDT	1460 CD	501	553 D	1220 D	767 D	666 D	15000
Total DDT[d]	**4455**	**1704**	**4302**	**4505**	**3779**	**4324**	**123972**
Dieldrin	**2520 CD**	**97.3**	**323 D**	**478 D**	**596 D**	**501 D**	**66700**
PCB Aroclors							
1242	183 U[e]	36.4 U	364 U	364 U	364 U	364 U	160000 U
1248	183 U	36.4 U	364 U	364 U	364 U	364 U	160000 U
1254	183 U	1160	1600 D	1520 D	10600 D	3410 D	160000 U
1260	183 U	36.4 U	364 U	364 U	364 U	364 U	160000 U

(a) 303.2 and 303.3 are Post-Remediation Station numbers for Lauritzen Channel/Mouth and Lauritzen Channel/End, respectively.
(b) C Associated surrogate recovery did not meet QC limits.
(c) D Sample extract diluted 10 times.
(d) Total DDT is sum of detected 2,4'-DDE, 4,4'-DDE, 2,4'-DDD, 4,4'-DDD, 2,4'-DDT, and 4,4'-DDT.
(e) U Analyte not detected at or above given concentration.

The most notable accumulation of pesticides on a passive sampler was measured in PS-2, which was deployed inside the 8-in. pipe protruding from the retaining wall on the northeast bank of Lauritzen Channel (Figure 3-2b). PS-2 concentrations were so high that the sample required repeated extraction and analysis of smaller polyethylene pieces to quantify DDT. This sampler was deployed approximately 1 week longer than the others, but its concentration is more than 25 times higher. This seems to indicate that the sampler was in contact with water, air, or sediment that had a very high concentration of DDT. Whether this pipe is a significant or continuing source of DDT to the channel is uncertain, as persistent high DDT exposure was not confirmed by three nearby samples:

1. Total DDT in PS-3, deployed in the water column approximately 25 ft away from the 8-in. pipe containing PS-2, was 4.3 ppm compared with the 124 ppm in PS-2.
2. Total DDT in S-2, the sediment sample grabbed from the 8-in. pipe prior to deployment of PS-2 and Y-TRAP-8, was less than 10 ppm, and
3. Sediment in Y-TRAP-8, which was deployed for the same duration as PS-2, was 0.5 ppm.

Concentrations of DDT and dieldrin in outfall-related samples are shown graphically in Figures 3-3 and 3-4, respectively. Samples collected in the vicinity of the 8-in. pipe and the concrete outfall had higher DDT and dieldrin concentrations than samples from the municipal outfall at the far north. Although there were relatively few outfalls and related samples in the southern part of Lauritzen Channel, the outfall-related data collected here reflect the general trend of decreasing DDT contaminations from north to south. The outfall data indicate that any potential upland source with an outfall pathway to the channel is in the northern half of the channel.

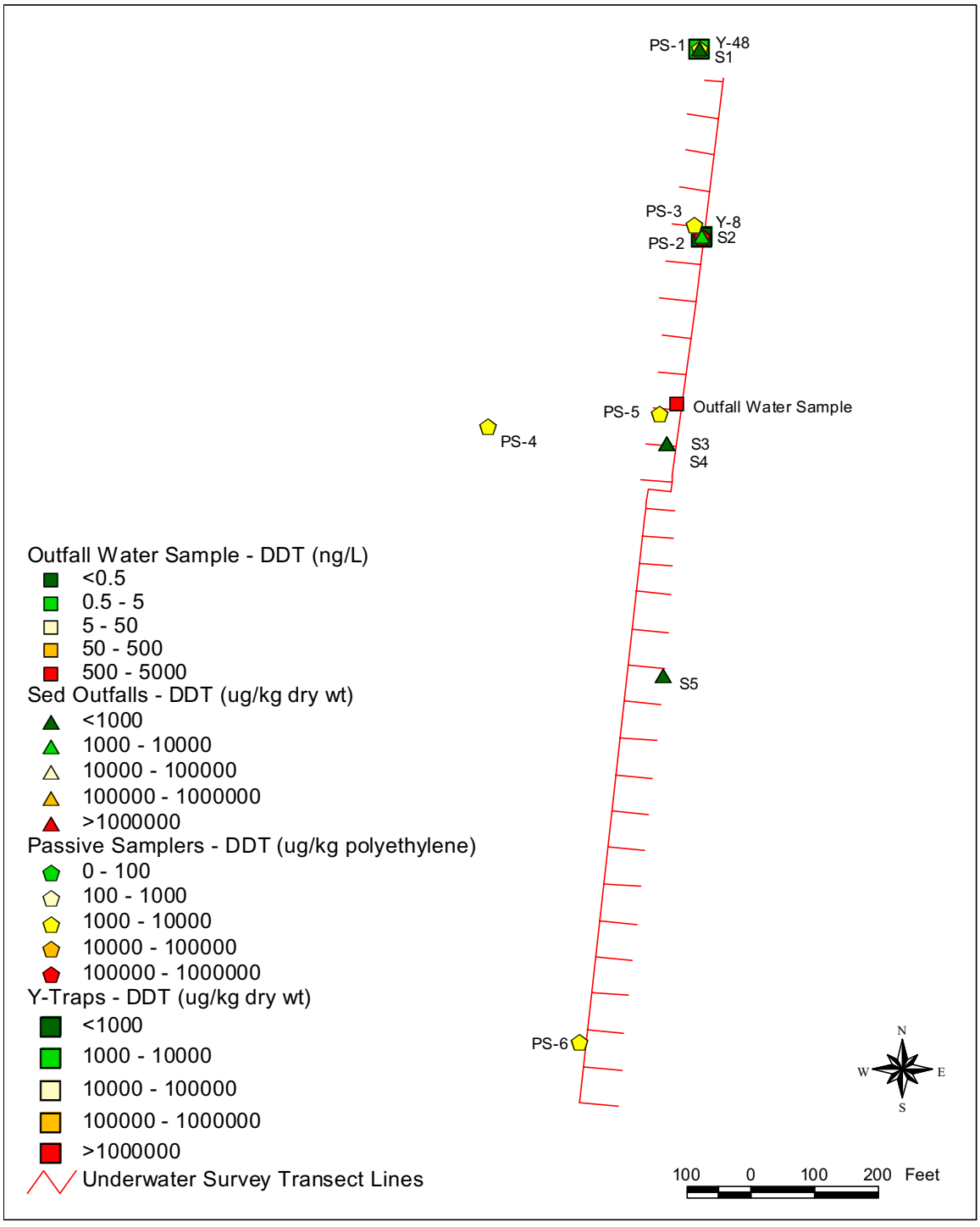


Figure 3-3. Outfall Water and Sediment DDT Concentrations in Lauritzen Channel

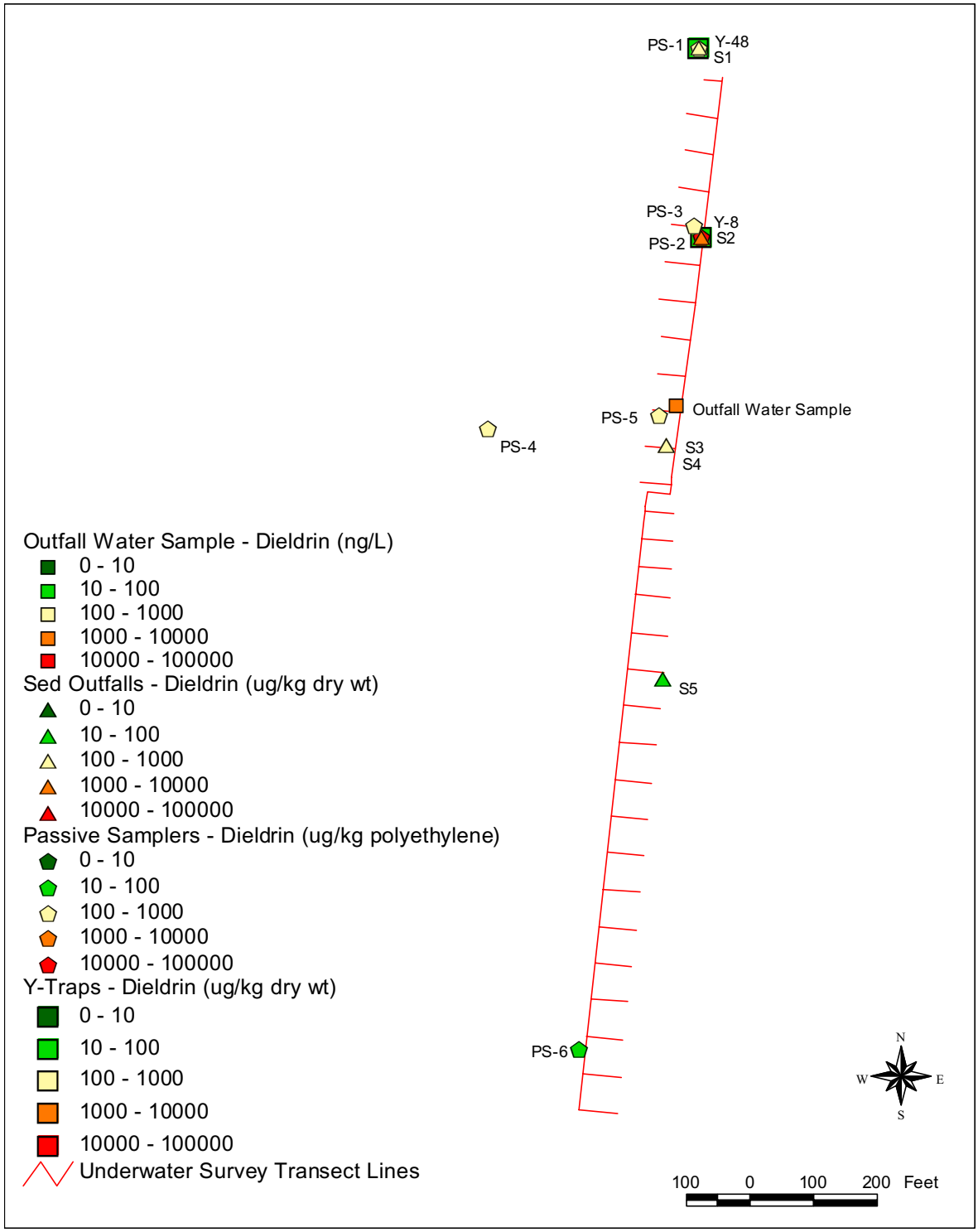


Figure 3-4. Outfall Water and Sediment Dieldrin Concentrations in Lauritzen Channel

3.2 LAURITZEN CHANNEL EAST BANK SURVEY

As described in Section 2, the primary task of the Lauritzen Channel East Bank survey was an underwater reconnaissance survey to document the present type, slope, and thickness of sediment under the Levin pier, identify the location of any additional outfall pipes, and identify potential sediment sampling locations. The second task of the East Bank survey was to collect sediment samples at locations of interest, both underwater in soft channel sediment and from intertidal or terrestrial soils on the embankment. This section presents the results of the underwater survey, sediment and bank soil collection, and chemical analyses. The condition of Lauritzen Channel East Bank at the time of the survey was documented on a videotape of the east bank; the video was recorded in the morning of March 15, 2002, when more natural light reached under the Levin Pier. The video and a brief narrative were delivered to EPA separately. Outfall pipe locations that were identified during this survey were discussed in Section 3.1.

3.2.1 Underwater Survey

The results of the underwater survey conducted by the Battelle MSL Dive Team are compiled in Table 3.4. Transect data are presented in order from south to north, starting at Transect +67.5 at the south end of the Levin Pier. Bathymetry and thickness of soft penetrable sediment in the area of the underwater survey is shown in Figure 3-5. Both the bathymetry and sediment plots in Figure 3-5 were generated using Surfer, and the extent of shading in the plots indicates the grid boundaries used in the calculation of soft sediment volume described in Section 2.2.3. Water depths were always deepest at the pier face (0 m on transect), approximately 30 ft MLLW along most of the pier, becoming shallower (approximately 23 ft MLLW) at the north end of Levin Berth C. Substrate types varied from soft silt, sand, and gravel at the pier face to steep clay banks to cobbles and boulders at the shoreline, usually covered with a layer of fine flocculent material that varied in thickness. The volume of soft sediment in the underwater survey area calculated by Surfer using default grid parameters was 830 cubic yards (cy). This volume is limited to the area surveyed by the divers and does not include transects north of –24.5, nor any soft sediment in the channel west of the Levin Pier face. In the 1999 Sediment Investigation, the volume of soft sediment in Lauritzen Channel was estimated at 12,770 cy using the same method.

Table 3.4. Lauritzen Channel East Bank Underwater Survey Transect Data

Transect	Distance In (m)	Water Depth (-ft)	Water Depth (-m)	Tide (ft)	Corrected Water Depth (-ft MLLW)	Date	Time	Soft Sediment Thickness (cm)	Surface Sediment Description	Transect Comments
+67.5	0	32	9.8	4.7	27.3	03/12/02	0855	5	gravel, fines on top	Very poor visibility at depth. Generally gravelly bottom, rip rap closer to shore, cable. Sponges visible on large rocks & boulders, 9 m. Steep slope up at 10 m on tape. Outfall pipe 2 gaps to south (T 69.5). Total transect length 19.2 m. Waterline is vertical wood retaining wall.
+67.5	3	27	8.2	4.7	22.3	03/12/02	0858	8	large gravel, sand, some fines	
+67.5	6	21	6.4	4.7	16.3	03/12/02	0859	10	gravel, small rocks with thin layer soft sed on top	
+67.5	9	15	4.6	4.7	10.3	03/12/02	0900	5	rocks, gravel, fine sed layer on top.	
+67.5	12	9	2.7	4.7	4.3	03/12/02	0903	8	fine floc over cobble, boulders, little amount on gravel	
+67.5	15	4	1.2	4.7	-0.7	03/12/02	0905	0	no fines cobble, boulder	
+67.5	18	2	0.6	4.7	-2.7	03/12/02	0906	1	mixed gravel, cobble boulders in vicinity	
+67.5	19.2	0	0.0	4.7	-4.7	03/12/02	0907	0	gravel & boulders	
+63.5	0	36	11.0	4.9	31.1	03/12/02	0921	11	gravel, mixed fines	Similar substrate as 67.5 Steep slope up at 9 m on tape. ~Equally mixed gravel, cobble, boulder at 15 m. Total transect length 19 m. Material at waterline has "slag" appearance.
+63.5	3	30	9.1	4.9	25.1	03/12/02	0923	8	fines over cobbles, gravel	
+63.5	6	23	7.0	4.9	18.1	03/12/02	0924	13	mixed fines over cobble, gravel	
+63.5	9	17	5.2	5.0	12.0	03/12/02	0925	5	mix of gravel & cobbles, boulders in vicinity	
+63.5	12	10	3.0	5.0	5.0	03/12/02	0927	10	fine sediment on gravel & cobbles	
+63.5	15	5	1.5	5.0	0.0	03/12/02	0928	0	mixed gravel, boulders, cobbles	
+63.5	18	2	0.6	5.0	-3.0	03/12/02	0930	1	cobble, gravel, large boulders	
+63.5	~19	0	0.0	5.0	-5.0	03/12/02	0930	0	same large cobble/boulder substrate	
+59.5	0	34	10.4	5.5	28.5	03/12/02	1027	10	mixed coarse gravel	Gravel bottom, difficult to get stake in. Large slab concrete and rubble at 13 m on tape. 1.5-m long I-beam at 16 m on tape. Large outfall, appears blocked, old, unused valved. Outfall pipe opens up approx. 0.6 m from shoreline (water/sed interface) it is 20 cm in diameter & perpendicular to shore line; propped up by pipe running parallel to shore (30 cm in diameter). Total transect length 17.7 m. I beams, debris at waterline.
+59.5	3	27	8.2	5.5	21.5	03/12/02	1035	5	fine sediment on top of mixed coarse gravel	
+59.5	6	21	6.4	5.5	15.5	03/12/02	1036	7	fine sed on top of mixed coarse gravel	
+59.5	9	15	4.6	5.5	9.5	03/12/02	1037	4	fine silt on top of gravel some cobble	
+59.5	12	8	2.4	5.5	2.5	03/12/02	1039	<1	mostly cobble, some fines on top	
+59.5	15	4	1.2	5.5	-1.5	03/12/02	1041	0	mixed large co sm boulder, no fines	
+59.5	-	-	0.0	5.5	-5.5	03/12/02	-	0		
+55.5	0	35	10.7	5.5	29.5	03/12/02	1055	40	fine flocculent over gravel	No visibility. Steep slope at 9 m on tape. Large structure at 12-13 m; possible to swim underneath (~3 ft opening) but tape goes over it. Total transect length 18.1 m, vertical rusty bulkhead.
+55.5	3	30	9.1	5.5	24.5	03/12/02	1057	35	fine flocculent over mixed sand, gravel, silt	
+55.5	6	23	7.0	5.5	17.5	03/12/02	1059	78	soft mud	
+55.5	9	17	5.2	5.5	11.5	03/12/02	1100	1	hard clay	
+55.5	12	12	3.7	5.5	6.5	03/12/02	1102	48	soft mud	
+55.5	15	5	1.5	5.5	-0.5	03/12/02	1104	0	rocks, debris	
+55.5	18	2	0.6	5.5	-3.5	03/12/02	1106	0	cobble, boulders, debris	
+55.5	18.1	0	0.0	5.5	-5.5	03/12/02	1108	0	to vertical rusty bulkhead	

Table 3.4. (contd)

Transect	Distance In (m)	Water Depth (-ft)	Water Depth (-m)	Tide (ft)	Corrected Water Depth (-ft MLLW)	Date	Time	Soft Sediment Thickness (cm)	Surface Sediment Description	Transect Comments
+51.5	0	35	10.7	5.4	29.6	03/12/02	1118	34	soft silt	At 3 m on tape: submerged lines 1.5 ft off bottom, piling brace 2 ft off bottom.3-6 m steep clay bank with piddocks, cut off or broken pilings 6-7 ft tall.Big boulder at 6 m, 2.5-3 ft rise on clay bank. 12 m on tape, transition to boulders, debris, cobble. Lots of metal debris at 15 m on tape. Total transect length 17.2 m. Metal bars holding back 1-2 ft concrete blocks.
+51.5	3	30	9.1	5.4	24.6	03/12/02	1120	33	soft silt	
+51.5	6	22	6.7	5.4	16.6	03/12/02	1121	0	hard clay	
+51.5	9	15	4.6	5.4	9.6	03/12/02	1123	6	soft silt over clay, many piddocks in clay bank	
+51.5	12	9	2.7	5.4	3.6	03/12/02	1124	40	soft silt between big boulders & cobble	
+51.5	15	5	1.5	5.4	-0.4	03/12/02	1127	0	debris, cobble, slag metal	
+51.5	17.2	0	0.0	5.3	-5.3	03/12/02	1129	0	metal holding back 1-2 ft concrete	
+47.5	0	36	11.0	4.7	31.3	03/12/02	1223	65	little bit of gravel sand, find sed.	Very low visibility. 9.5 m on tape: steep clay bank, many piddocks 13 m on tape: steep rise 14 m, big coil, metal debris. Total transect length 19 m, vertical metal wall holding back square blocks of rock.
+47.5	3	32	9.8	4.5	27.5	03/12/02	1237	30	fine sed over ~gravel	
+47.5	6	26	7.9	4.5	21.5	03/12/02	1239	2	thin layer of fine sediment on firm clay bank w/ piddocks	
+47.5	9	19	5.8	4.4	14.6	03/12/02	1240	7	hard clay bank not as steep as at 6 m	
+47.5	12	13	4.0	4.4	8.6	03/12/02	1242	8	soft silt over hard clay	
+47.5	15	5	1.5	4.4	0.6	03/12/02	1244	1	thin fine layer over rubble, debris	
+47.5	18	1	0.3	4.4	-3.4	03/12/02	1246	0	1 sq ft blocks of rock	
+47.5	19	0	0.0	4.3	-4.3	03/12/02	---	0	vertical metal wall holding back rocks	
+43.5	0	36	11.0	4.0	32.0	03/12/02	1305	10	fine flocculent on mixed coarse gravel	Visibility improving. 14m to metal debris. Total transect length 16.5 m; ends at vertical wall.
+43.5	3	27	8.2	4.0	23.0	03/12/02	1308	25	fine flocculent over gravel	
+43.5	6	25	7.6	3.9	21.1	03/12/02	1311	40	fine flocculent over clay - soft	
+43.5	9	17	5.2	3.9	13.1	03/12/02	1312	10	fines over clay	
+43.5	12	11	3.4	3.8	7.2	03/12/02	1313	8	thin fine sediment boulders, debris, ropes cables	
+43.5	15	5	1.5	3.8	1.2	03/12/02	1314	2	boulders & debris near mixed coarse gravel	
+43.5	16.5	2	0.6	3.8	-1.8	03/12/02	1316	0	vertical large coarse gravel, boulders, 1 ft blocks	
+39.5	0	32	9.8	2.2	29.8	03/12/02	1425	50	top layer very soft, flocculant silt, sandy soft mud	9-12 m: hard steep clay bank with piddocks Total transect length 15 m, rip rap banc up to metal bulkhead. Tide is lower than this morning so easier to see in under pier.
+39.5	3	26	7.9	2.1	23.9	03/12/02	1427	38	soft flocculent material, silty mud, scattered cobble	
+39.5	6	20	6.1	2.1	17.9	03/12/02	1428	25	soft flocculent silty mud, scattered cobble & boulders	
+39.5	9	14	4.3	2.1	11.9	03/12/02	1430	10	silty mud over hard clay	
+39.5	12	6	1.8	2.1	3.9	03/12/02	1431	5	soft floccy clay over hard clay	
+39.5	15	0	0.0	2.1	-2.1	03/12/02	1432	0	boulders, debris, trash	
+35.5	0	32	9.8	1.9	30.1	03/12/02	1441	37	very soft flocculent, silty mud	Compasses not working under pier- metal debris? Total transect length 15.2 m
+35.5	3	26	7.9	1.9	24.1	03/12/02	1442	25	soft flocc. on silty mud, scattered cobbles, rocks	
+35.5	6	20	6.1	1.9	18.1	03/12/02	1444	4	soft flocc. on gravel & cobbles	
+35.5	9	13	4.0	1.8	11.2	03/12/02	1445	2	soft flocc. on gravel & cobbles	
+35.5	12	7	2.1	1.7	5.3	03/12/02	1446	5	flocculent over gravel & cobbles	
+35.5	15	1.5	0.5	1.7	-0.2	03/12/02	1447	0	cobbles, boulders debris	

Table 3.4. (contd)

Transect	Distance In (m)	Water Depth (-ft)	Water Depth (-m)	Tide (ft)	Corrected Water Depth (-ft MLLW)	Date	Time	Soft Sediment Thickness (cm)	Surface Sediment Description	Transect Comments
+31.5	0	32	9.8	1.5	30.5	03/12/02	1458	16	muddy silt	Clay bank w/piddocks at 11 m.
+31.5	3	27	8.2	1.5	25.5	03/12/02	1500	12	muddy silt, floc over hard clay	Out fall pipe ~6 in diameter, looks like it may discharge occasionally.
+31.5	6	20	6.1	1.5	18.5	03/12/02	1501	28	muddy silt, fine floc scattered large debris	Total transect length 15.2 m.
+31.5	9	14	4.3	1.5	12.5	03/12/02	1503	5	fines on cobbles, rock, boulders	
+31.5	12	7	2.1	1.5	5.5	03/12/02	1504	0	hard clay bank, piddocks	
+31.5	15	1	0.3	1.4	-0.4	03/12/02	1506	0	metal debris on clay bank; cobbles, boulders	
+31.5	15.2	0	0.0	1.4	-1.4	03/12/02	---	0	same as above	
+27.5	0	31	9.4	1.2	29.8	03/12/02	1515	10	light silty mud mixed w/ gravel	3-6 m: debris, metal & cable pilings
+27.5	3	24	7.3	1.2	22.8	03/12/02	1516	10	soft flocc. Over gravel w/ cobbles	Outfall: black corrugated 18" pipe, water coming out (interceptor outfall).
+27.5	6	18	5.5	1.1	16.9	03/12/02	1518	0	steep bank, big rocks on clay	Total transect length 14.5 m
+27.5	9	13	4.0	1.1	11.9	03/12/02	1518	0	steep bank cobbles, gravel, boulders	
+27.5	12	7	2.1	1.1	5.9	03/12/02	1519	0	gravel, cobbles, boulders	
+27.5	14.5	0	0.0	1.1	-1.1	03/12/02	1521	0	cobbles, gravel, boulders	
+23.5	0	35	10.7	4.8	30.2	03/13/02	958	28	soft mud, clay	Compasses way off--not usable under pier.
+23.5	3	30	9.1	4.8	25.2	03/13/02	1000	35	very soft flocculent, possibly gravel underneath	Incline to hard clay at 6 m.
+23.5	6	24	7.3	4.8	19.2	03/13/02	1001	0	begin incline, hard clay	Boulders and cobbles visible on clay at 10 m.
+23.5	9	17	5.2	4.8	12.2	03/13/02	1002	8	soft silt over lying hard clay	Steep "wall" at 12 m, piddocks in clay.
+23.5	12	10	3.0	4.8	5.2	03/13/02	1004	0	vertical clay	Total transect length 17.7 m; 0.5 m horizontal distance to vertical bulkhead from waterline.
+23.5	15	5	1.5	4.8	0.2	03/13/02	1005	0	some gravel, boulder, cobble, rock over clay	
+23.5	17.7	0	0.0	4.8	-4.8	03/13/02	1006	0	boulders, rocks	
+19.5	0	35	10.7	5.0	30.0	03/13/02	1016	59	very soft mud & silt	6 m: clay bank.
+19.5	3	29	8.8	5.0	24.0	03/13/02	1018	18	very soft silty clay	10-12 m: piddocks in clay.
+19.5	6	23	7.0	5.0	18.0	03/13/02	1019	7	vertical clay bank fine clay on hard clay	Total transect length 17.0 m; vertical bulkhead
+19.5	9	16	4.9	5.0	11.0	03/13/02	1021	10	soft silt on hard clay, scattered cobbles & rocks	
+19.5	12	10	3.0	5.0	5.0	03/13/02	1022	5	silt on hard clay	
+19.5	15	4	1.2	5.0	-1.0	03/13/02	1023	0	boulders, cobbles, gravel over clay	
+19.5	17	0	0.0	5.0	-5.0	03/13/02	1025	N/A	vertical bulkhead	
+15.5	0	31	9.4	5.1	25.9	03/13/02	1036	31	soft flocculent	Lots of pilings submerged, not visible from surface.
+15.5	3	26	7.9	5.1	20.9	03/13/02	1037	30	soft silt, flocculent	4 m: vertical clay bank.11 m: vertical clay wall, piddocks.
+15.5	6	19	5.8	5.1	13.9	03/13/02	1038	8	soft silt over clay	Total transect length 15.7 m; boulders & cobbles above water.
+15.5	9	14	4.3	5.2	8.8	03/13/02	1039	3	soft silt over clay	
+15.5	12	6	1.8	5.2	0.8	03/13/02	1040	12	concrete, red bauxite, soft silt over clay	
+15.5	15	1	0.3	5.2	-4.2	03/13/02	1042	0	boulders cobbles, red bauxite	
+15.5	15.7	0	0.0	5.2	-5.2	03/13/02	1043	0	same as above, above water	
+11.5	0	28	8.5	5.2	22.8	03/13/02	1200	15	gravel mixed in with clay, silt, flocc.	2 m: cable sticking up from bottom, tape taken over cable.
+11.5	3	21	6.4	5.2	15.8	03/13/02	1202	5	thin layer silt/floc on hard clay	0-3 m: transition to hard clay bank.
+11.5	6	15	4.6	5.2	9.8	03/13/02	1203	5	gravelly silt over hard clay	7 m: steep clay bank.
+11.5	9	8	2.4	5.2	2.8	03/13/02	1205	3	gravelly silt over hard clay	10-11 m: boulders and debris.
+11.5	12	2.5	0.8	5.2	-2.7	03/13/02	1206	0	gravel cobble, boulders	Total transect length 14.0 m.
+11.5	14	0	0.0	5.2	-5.2	03/13/02	1207	0	cobble, boulder. Hard clay mixed w/ fill.	

Table 3.4. (contd)

Transect	Distance In (m)	Water Depth (-ft)	Water Depth (-m)	Tide (ft)	Corrected Water Depth (-ft MLLW)	Date	Time	Soft Sediment Thickness (cm)	Surface Sediment Description	Transect Comments
+8.5	0	28	8.5	5.1	22.9	03/13/02	1222	23	silt & mud mixed with cobble, gravel	Ran into crossed pilings at planned Transect 7.5, determined it was not a safe transect. Transect 8.5 was substituted, and spacing was reduced to every 3rd gap from T 8.5 to north end of Levin Pier. 7 m: start of clay bank with piddocks. 7.5 m: debris. Total transect length 13.7 m; No vertical sheetpile above water line (but there is at T 5.5).
+8.5	3	21	6.4	5.1	15.9	03/13/02	1223	7	gravelly silt	
+8.5	6	14	4.3	5.1	8.9	03/13/02	1225	13	soft silt w/ gravel	
+8.5	9	8	2.4	5.1	2.9	03/13/02	1228	6	soft silt over clay bank	
+8.5	12	3	0.9	5	-2.0	03/13/02	1229	0	boulder, cobbles	
+8.5	13.7	0	0.0	5	-5.0	03/13/02	1229	0	mixed cobble, rock over clay	
+5.5	0	28	8.5	4.9	23.1	03/13/02	1239	12	light silt, mixed w/ cobbles, gravel	Rocks near 0 m. Clay bank at 3 m, piddocks everywhere. 8.5 m: clay bank ends, change to cobble & debris. 11 m: geotextile fabric under rip rap Large round concrete piling in center of gap near shore; tape placed to right of piling. Total transect length 13.7 m; vertical bulkhead right at water line.
+5.5	3	22	6.7	4.9	17.1	03/13/02	1240	5	light silt cobbles boulders.	
+5.5	6	15	4.6	4.8	10.2	03/13/02	1242	2	silt over clay	
+5.5	9	8	2.4	4.8	3.2	03/13/02	1244	1-2	gravelly	
+5.5	12	2	0.6	4.8	-2.8	03/13/02	1245	0	gravel, cobbles	
+5.5	13.7	0	0.0	4.8	-4.8	03/13/02	1246	0	waterline at sheet pile	
+2.5	0	28	8.5	4.6	23.4	03/13/02	1257	18	lots of boulders & cobble, soft sed in pockets between	7-9 m: almost vertical clay bank, full of piddocks. 11.5 m: erosion resistant/geotextile Total transect length 13.3 m; 10 cm away from vertical wall.
+2.5	3	21	6.4	4.6	16.4	03/13/02	1258	8	some light sed between cobble boulders, gravel	
+2.5	6	15	4.6	4.6	10.4	03/13/02	1259	3	silt mixed w/ gravel, cobbles boulders	
+2.5	9	7	2.1	4.6	2.4	03/13/02	1300	0	hard clay	
+2.5	12	2	0.6	4.6	-2.6	03/13/02	1301	0	boulder, gravel, rock, cobble over geotextile	
+2.5	13.3	0	0.0	4.6	-4.6	03/13/02	1302	0	cobble rock, boulder	
-0.5	0	26	7.9	2.9	23.1	03/13/02	1428	10	fine flocculent over sandy gravel	4.7 m: bay pipefish 5 m: steep clay bank. 7.5 m: bench; clay bank starts to level out but steep again at 9 m. Total transect length 12.6 m.
-0.5	3	23	7.0	2.9	20.1	03/13/02	1429	25	fine silty mud over clay	
-0.5	6	15	4.6	2.9	12.1	03/13/02	1432	1	steep clay bank, thin layer fines	
-0.5	9	10	3.0	2.9	7.1	03/13/02	1433	2	fine silty clay over hard clay	
-0.5	12	2	0.6	2.8	-0.8	03/13/02	1435	2	fine silty clay over hard clay	
-0.5	12.6	0	0.0	2.8	-2.8	03/13/02	1436	0	cobbles, boulders	
-4.5	0	20	6.1	2.6	17.4	03/11/02	1330	48	soft flocculent surface, sandy beneath	Transect is near aluminum ramp down to floating dock. Visibility very poor, <2 ft. Piddocks present (indicates clay bank) Total transect length not recorded; still 2.5 ft water at 11 m on tape. Horizontal distance 8.5 m pier-to-I-beam measured with tape on wooden pier just north of aluminum ramp. I-beam to land is 3 m; total horizontal distance is 11.5 m
-4.5	1	23	7.0	2.6	20.4	03/11/02	1328	9		
-4.5	3	20	6.1	2.6	17.4	03/11/02	1328	7		
-4.5	7	11	3.4	2.6	8.4	03/11/02	1327	5	clay, 5 cm silt	
-4.5	9	7	2.1	2.6	4.4	03/11/02	1326	0	clay, no fines	
-4.5	11	2.5	0.8	2.6	-0.1	03/11/02	1325	0	clay, no fines	
-8.5	0	19	5.8	2.3	16.7	03/11/02	1340	NM	light silt	Horizontal distance 8.5 m measured with tape on wooden pier just north of aluminum ramp, plus 3 m to land = 11.5 m. total horizontal distance. Very steep slope at 1 m in on tape. Total transect length not recorded; still 3 ft water at ~9 m (log book says 5 m but probably means 7+2=9 m)
-8.5	1	18	5.5	2.3	15.7	03/11/02	1341	10	light silt	
-8.5	3	13	4.0	2.3	10.7	03/11/02	1342	1-2	silt on steep clay	
-8.5	5	9	2.7	2.3	6.7	03/11/02	1343	7	silt	
-8.5	7	6	1.8	2.3	3.7	03/11/02	1344	5	silt on top of clay	
-8.5	9	3	0.9	2.3	0.7	03/11/02	1345	0	hard clay	

Table 3.4. (contd)

Transect	Distance In (m)	Water Depth (-ft)	Water Depth (-m)	Tide (ft)	Corrected Water Depth (-ft MLLW)	Date	Time	Soft Sediment Thickness (cm)	Surface Sediment Description	Transect Comments
-12.5	0	17	5.2	0.6	16.4	03/11/02	1511	10	fine floccy silt, 2-4 cm gravel	Gradual to 5m, then steep. 10m to water line @ cobble/rip rap bank. Variable "fill-like" material (sand + gravel). Transition to boulders, cobble at 4 m on tape. Sharp line to clay bank at 6.7 m on tape; height of clay bank is 0.7 m vertical. Total transect length 10 m.
-12.5	3	13	4.0	0.6	12.4	03/11/02	1513	5-10	very fine layer of floc silt on coarse sand, gravel	
-12.5	6	9	2.7	0.6	8.4	03/11/02	1516	2	soft silt on gravel	
-12.5	9	2	0.6	0.5	1.5	03/11/02	1518	2	silt	
-12.5	10	0	0.0	0.5	-0.5	03/11/02	1518	0		
-16.5	0	18	5.5	0.3	17.7	03/11/02	1528	8	fine flocculent, over ~ sand	Steep slope upward at 7 m (noted at 9.5 m on tape by 2nd diver); transition to boulders at 8 m. Steep clay bank, scattered cobbles, boulders above waterline Tide is +0.3 ft at 1530. Total transect length 11.9 m
-16.5	3	16	4.9	0.3	15.7	03/11/02	1529	0	cobbles	
-16.5	6	13	4.0	0.3	12.7	03/11/02	1531	0	boulders	
-16.5	9	7	2.1	0.3	6.7	03/11/02	1532	5	soft floc mixed with gravel	
-16.5	12	0	0.0	0.3	-0.3	03/11/02	1534	0	scattered cobble, boulders on steep clay bank	
-20.5	0	18	5.5	0.1	17.9	03/11/02	1544	26	fine silt	18 ft at 0, soft bottom. Red rock crab and coot observed near shore. Change to steep incline at 8.4 m. Piddocks present, so clay underlying. Cobbles above waterline, silt below. Total transect length 14.5 m.
-20.5	3	17	5.2	0.1	16.9	03/11/02	1545	23	fine silt	
-20.5	6	14	4.3	0.1	13.9	03/11/02	1546	32	fine silt	
-20.5	9	8	2.4	0.1	7.9	03/11/02	1548	5	fine silt over clay	
-20.5	12	3	0.9	0.1	2.9	03/11/02	1550	4	fine silt	
-20.5	14.5	0	0.0	0.1	-0.1	03/11/02	---	0	steep cobble bank	
-24.5	0	19	5.8	0.2	18.8	03/11/02	1604	32	very fine silt	19 ft at 0, nudibranch at 4m Steep incline at 6.5 m; thin layer of fine silt over clay Slope levels off at 10.5 m Total transect length 12.5 m.
-24.5	3	17	5.2	0.3	16.7	03/11/02	1605	25	fine silt	
-24.5	6	12	3.7	0.3	11.7	03/11/02	1606	25	fine silt	
-24.5	9	6	1.8	0.3	5.7	03/11/02	1608	2.5	fine silt, floc over clay & gravel, some big rocks	
-24.5	12	1	0.3	0.3	0.7	03/11/02	1610	5	fine silt over small boulders	
-24.5	12.5	0	0.0	0.3	-0.3	03/11/02	---	0	steep boulders	

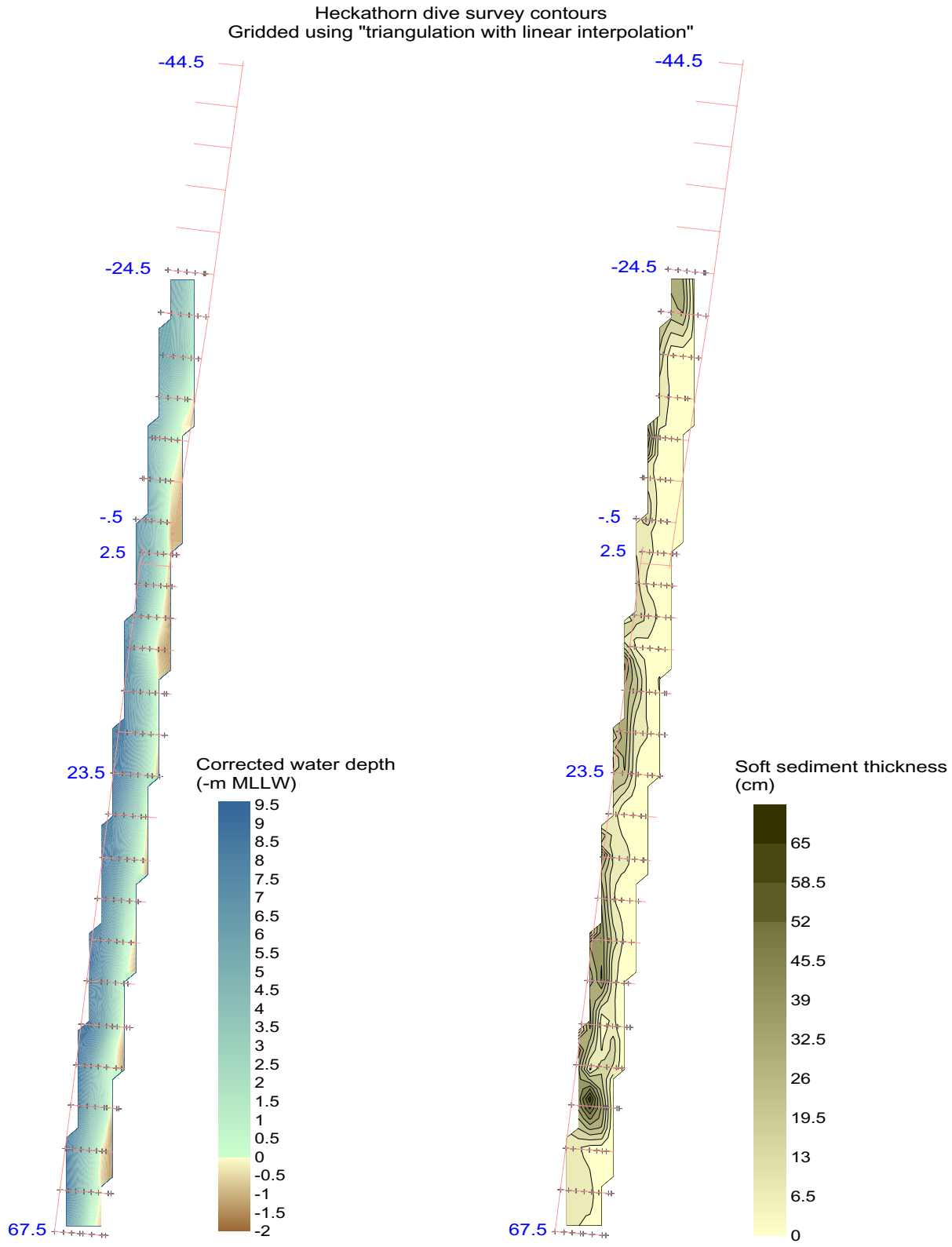


Figure 3-5. Bathymetry and Soft Sediment Thickness in the Underwater Survey Area

The still photographs in Figure 3-6, captured from an underwater video of Transect +2.5, show the appearance of the various substrates typically encountered along the underwater survey transects. A graphical profile of each surveyed transect is provided in Figure 3-7 through Figure 3-15, in order from south to north starting with Transect +67.5. These profiles are smoothed between transect data points; actual profiles have a more irregular slope and roughness on a fine scale, as is visible in Figure 3-6. The series of profiles shows how the overall slope and width of the survey area change as one moves up the channel, as well as the distribution of penetrable sediment along the transect. The southernmost Transects +67.5 through +59.5 were characterized by consistently sloped banks (20º to 25º) of course gravel, cobbles, and boulders with less than 15 cm fine sediment accumulation. From Transect +55.5 north to Transect +43.5, slope angle increased slightly up to 30º, and a slight bench feature containing accumulated soft sediment between steeper slopes appears in some of the profiles, e.g. Transect +43.5 (Figure 3-9). In this section, substrate was generally finer with more clay noted beneath large boulders and cobbles, and deposits of soft sediment 40-65 cm thick had accumulated at the toe of the slope at the pier face. The slope became more consistent (generally about 23º) between Transects +39.5 and +19.5, with up to 60 cm muddy silt accumulated on the lower part of the slope. From Transect +15.5 to Transect +2.5 at the north end of the Levin pier, survey area width narrowed to 8-10 m and the average slopes steepened slightly to 25-30º with distinct steep clay banks noted in all transects. The divers noted piddock siphons throughout the steep clay banks between Transects +51.5 and -4.5, and occasionally further north (e.g., Transect –20.5). Piddocks are bivalves that drill into rock or clay. They filter-feed with distinctive split siphons (Figure 3-6). The species observed along the east bank of Lauritzen Channel was most likely the rough piddock, *Zirfaea pilsbryi*, a species that drills in stiff clay.

North of the Levin pier, between Transects -0.5 and -24.5, the channel bank was inconsistently sloped and characterized by fine flocculent material overlying clay and occasionally course sand and gravel, with very few cobbles or boulders noted except at the water line. Parts of this section of the bank were excavated during upland cleanup actions in the early 1990s (Figure 2-4). The underwater survey area did not extend north of Transect -24.5.

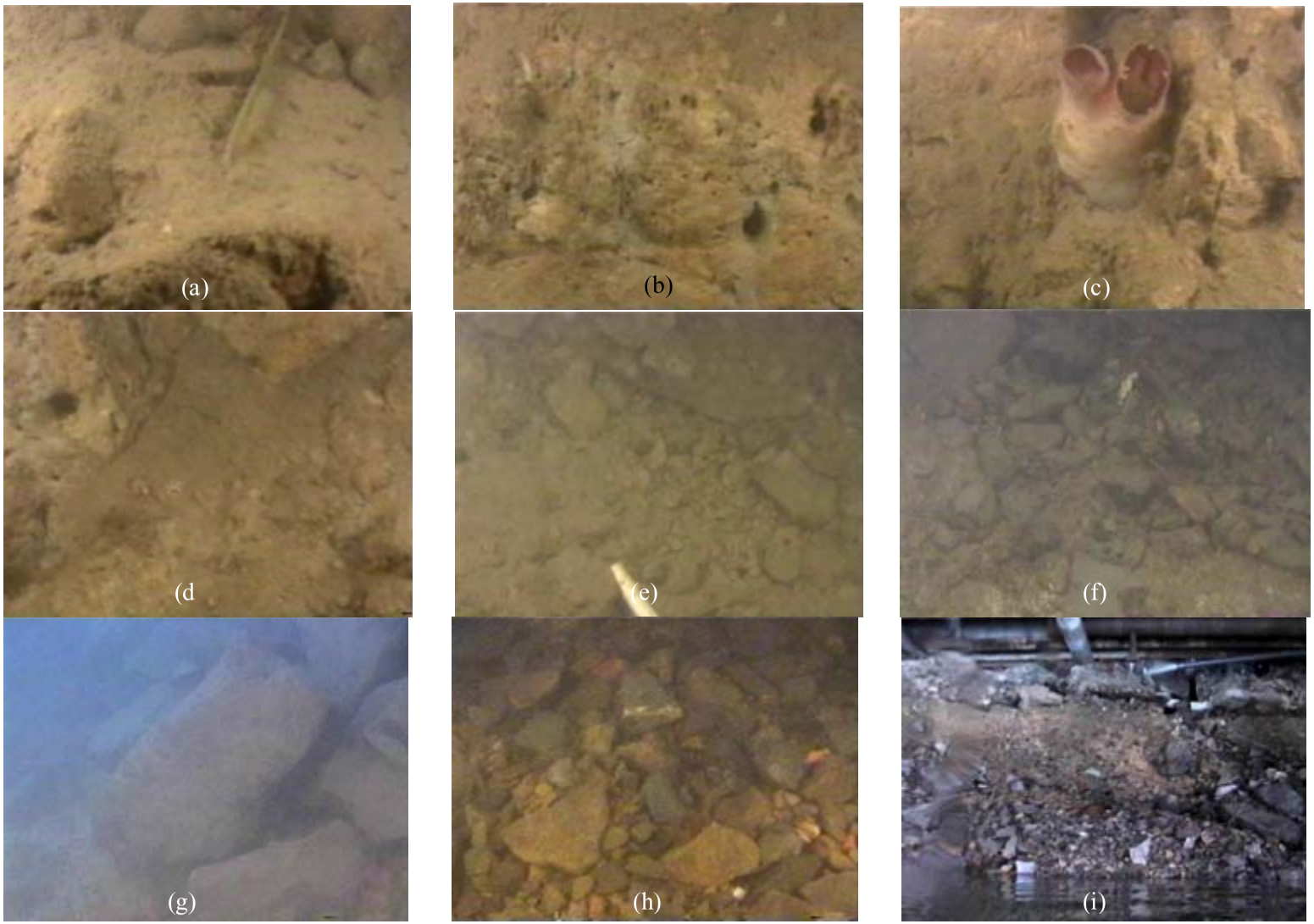
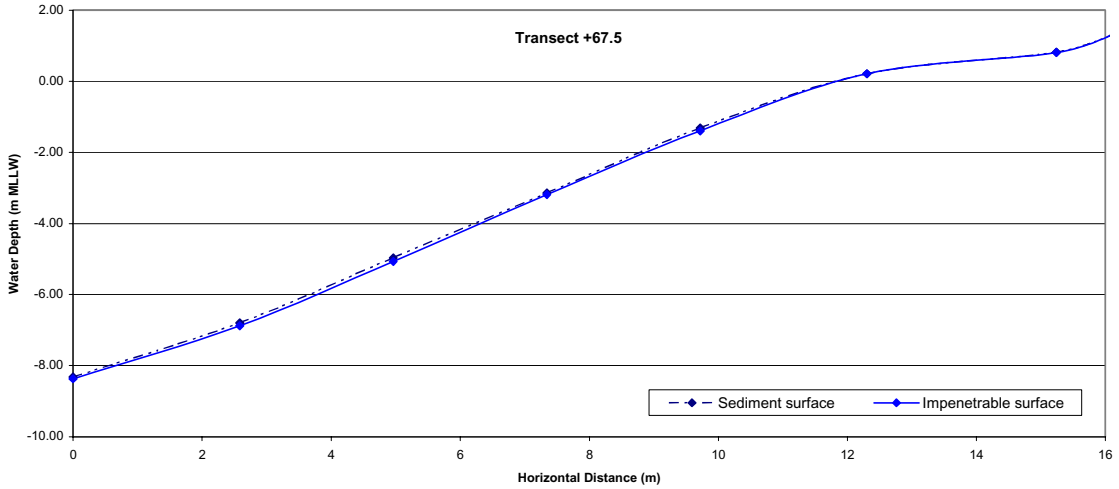
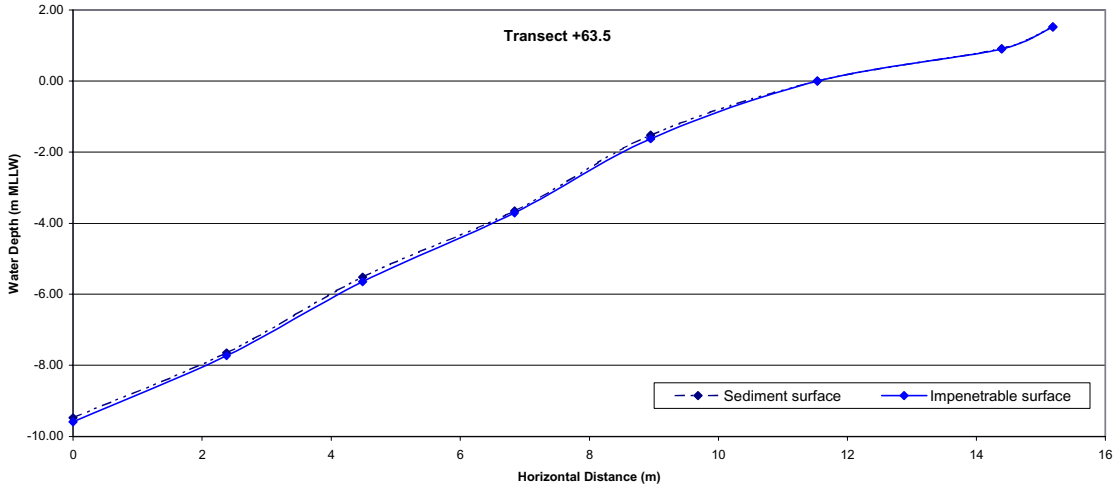


Figure 3-6. Typical substrate sequence under Levin Pier (from Transect +2.5 video). Soft flocculent material with occasional cobbles (a), steep clay bank (b) with piddock clam siphons (c), thin flocculent layer on uneven clay (d), transition from clay to mixed coarse gravel and cobbles with small debris (e) to cobble and boulder fill (f, g, h), overlying geotextile fabric near the water's edge (i).





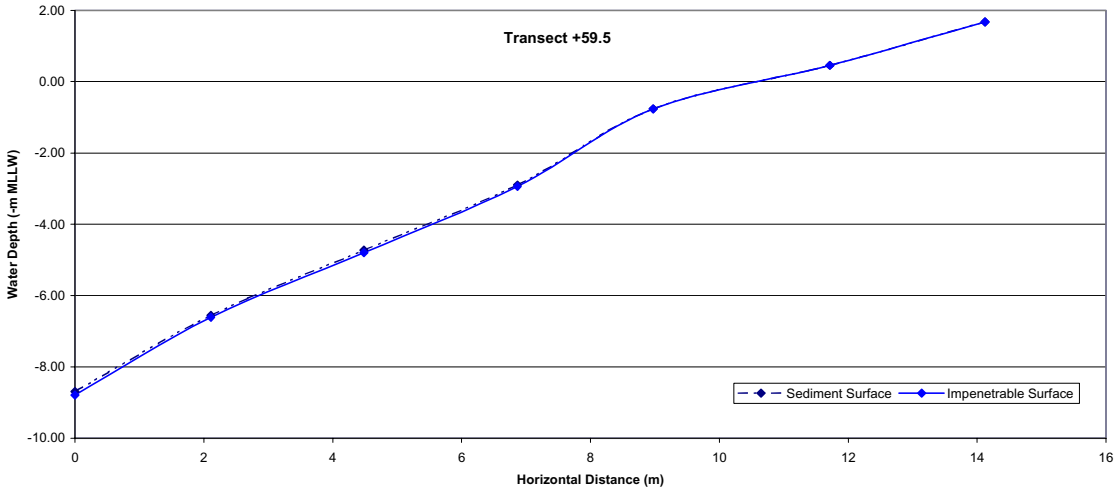
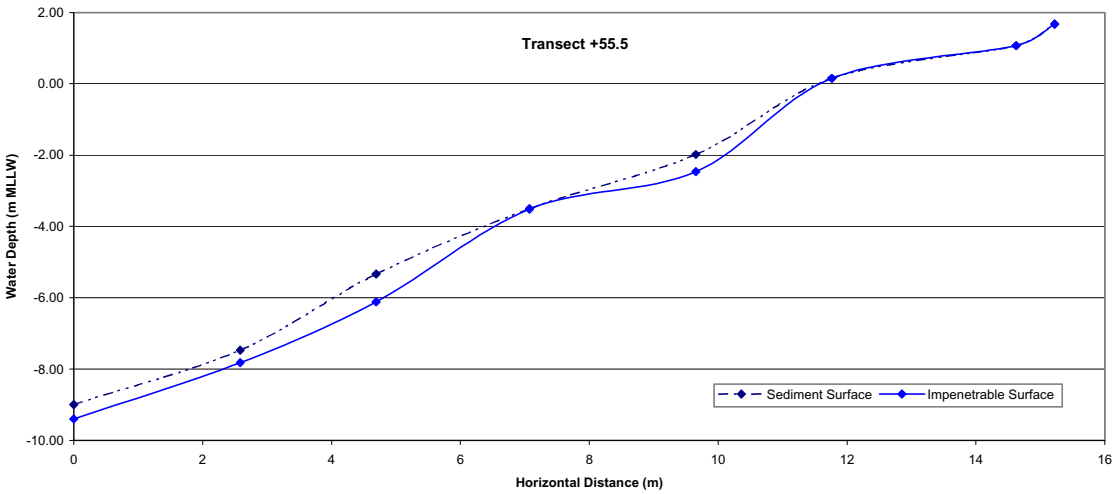
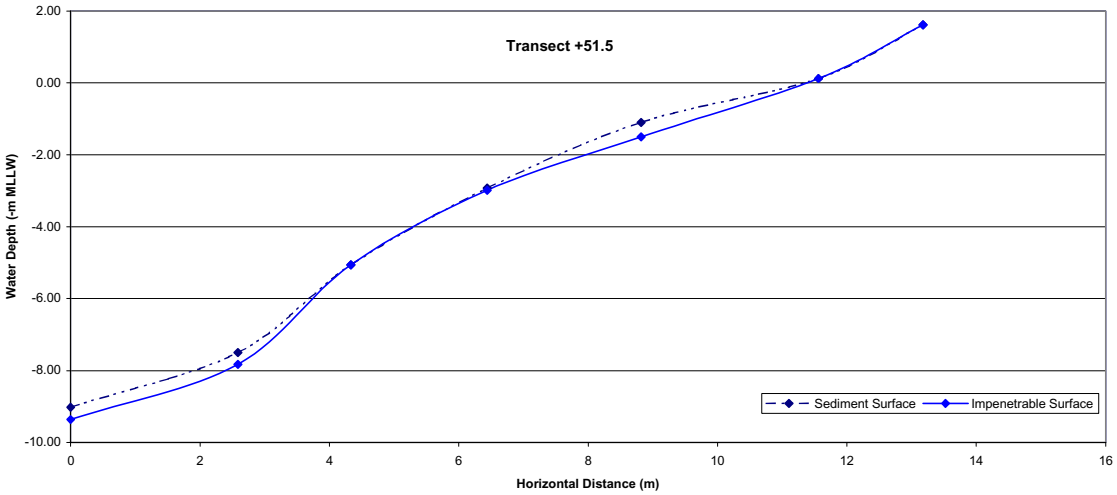


Figure 3-7. Underwater Survey Profiles for Transects +67.5, +63.5, and +59.5





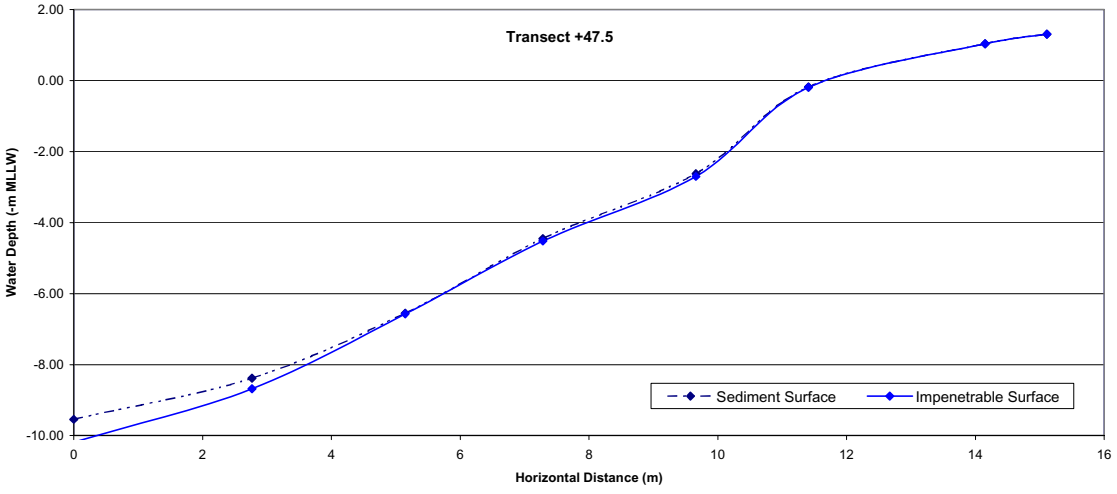
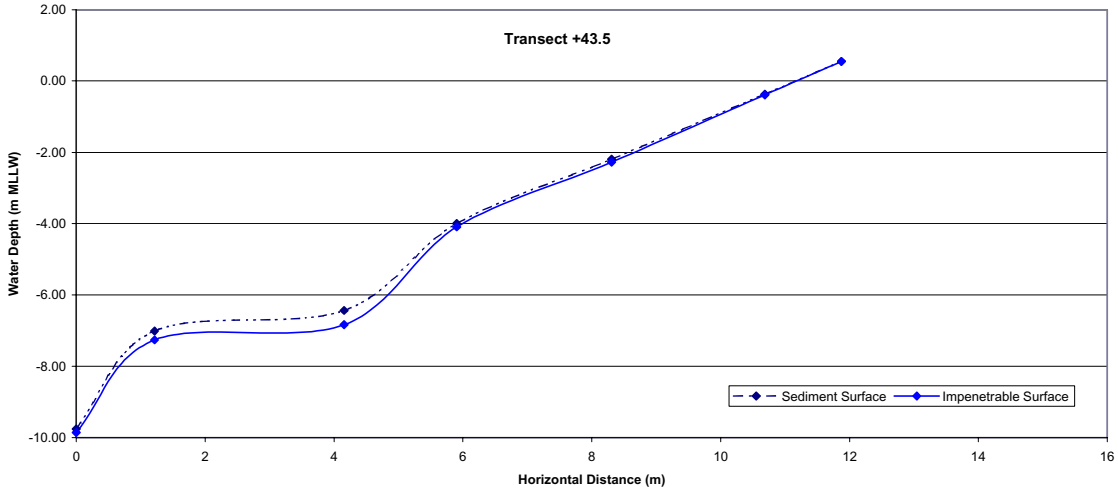
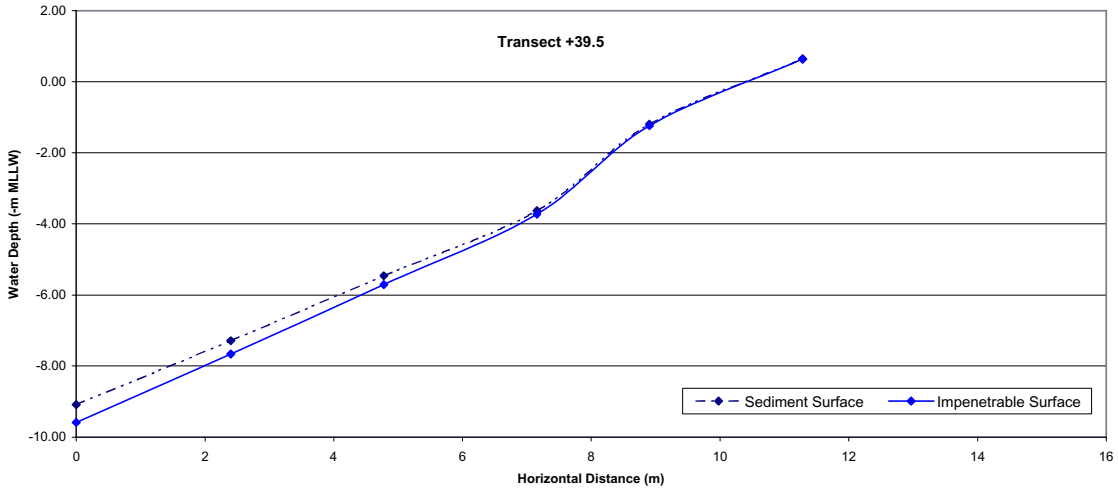


Figure 3-8. Underwater Survey Profiles for Transects +55.5, +51.5, and +47.5





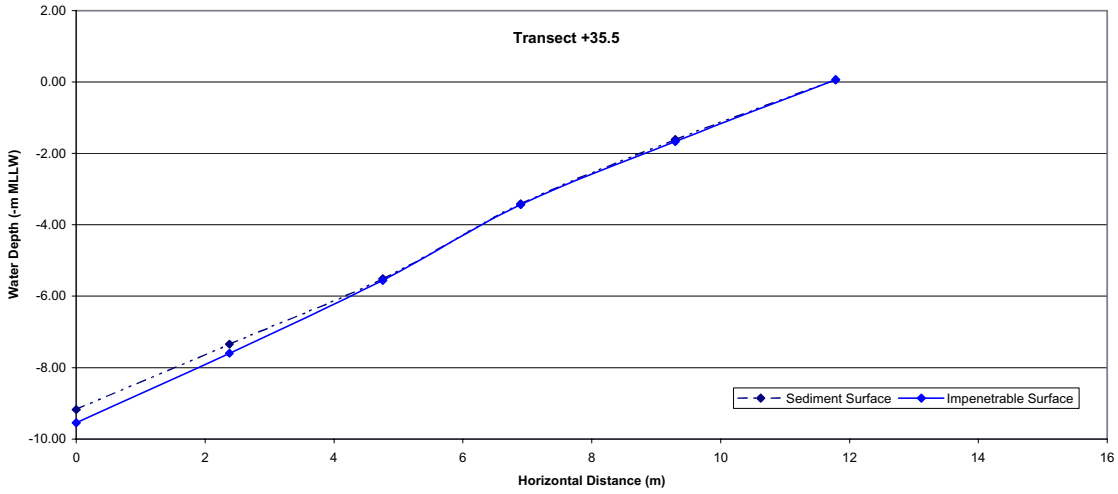


Figure 3-9. Underwater Survey Profiles for Transects +43.5, +39.5, and +35.5

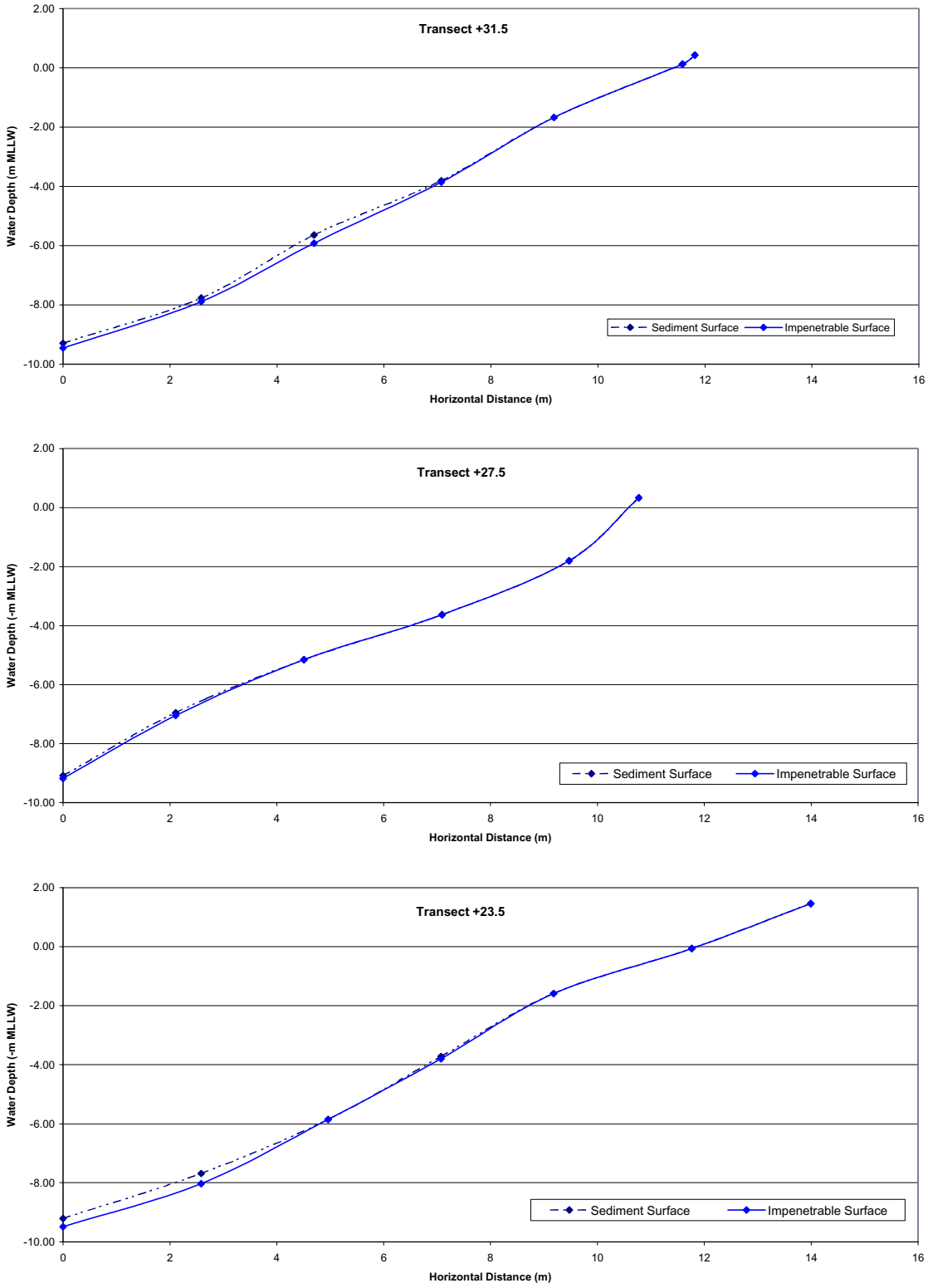


Figure 3-10. Underwater Survey Profiles for Transects +31.5, +27.5, and +23.5

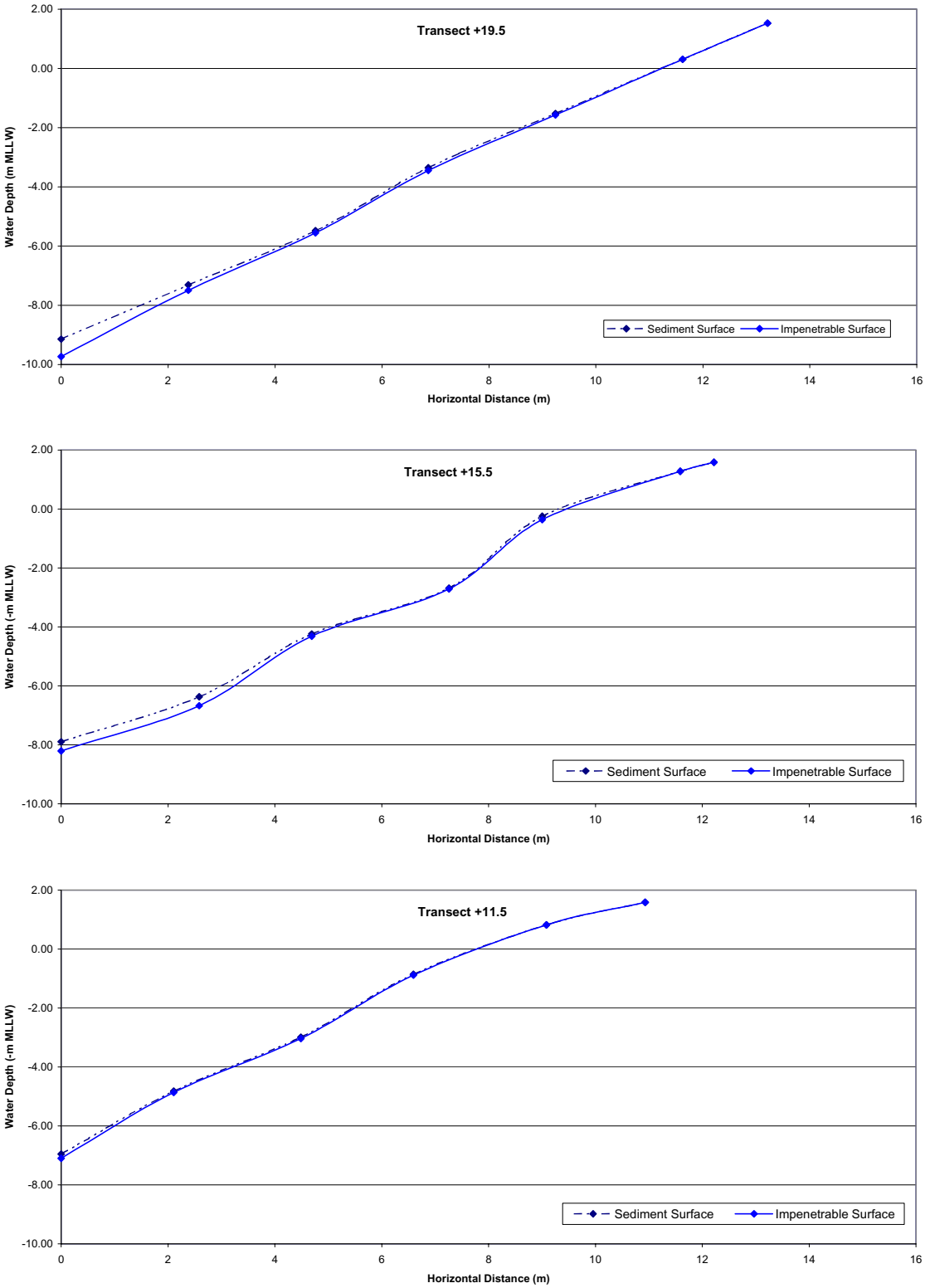


Figure 3-11. Underwater Survey Profiles for Transects +19.5, +15.5, and +11.5

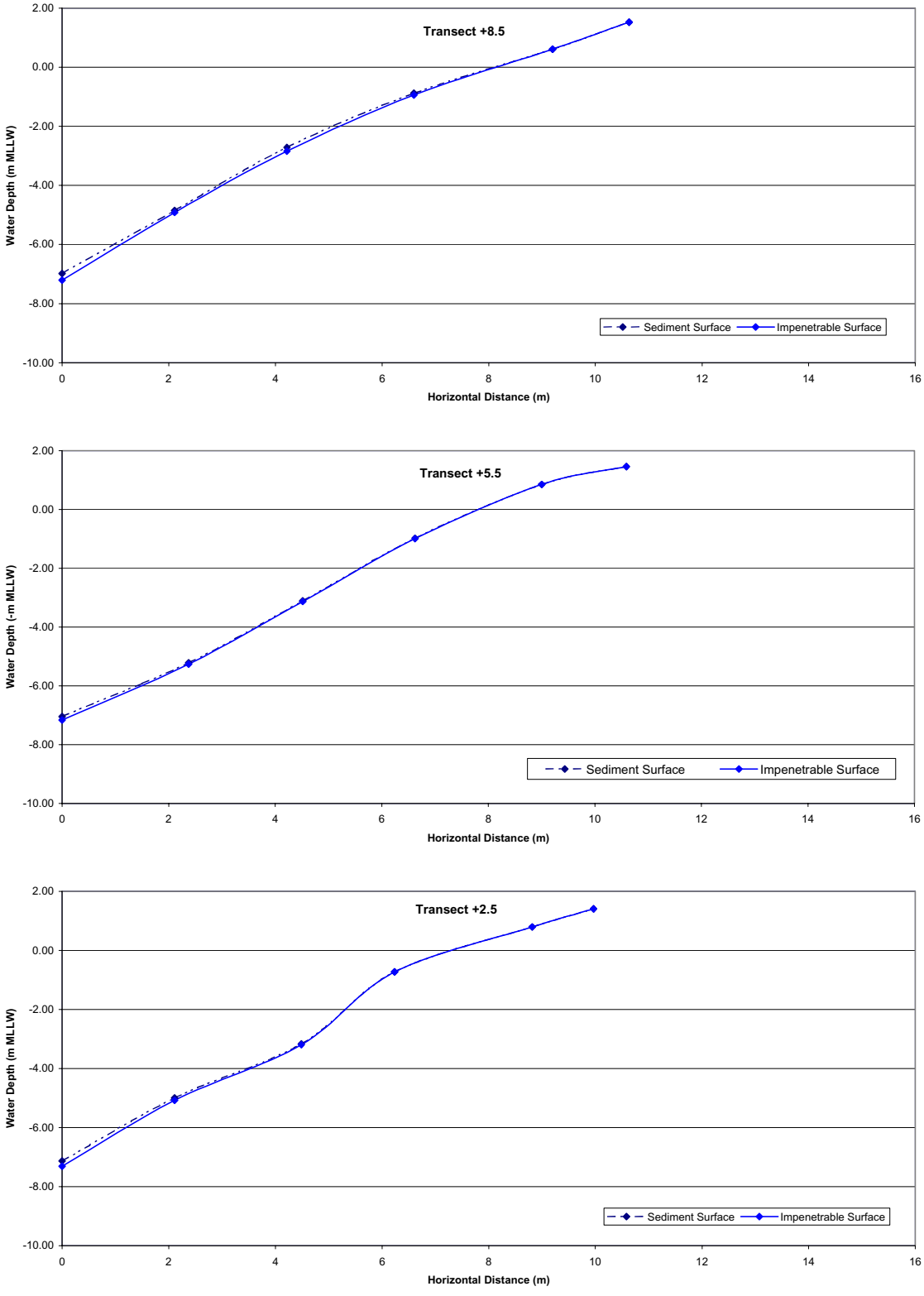


Figure 3-12. Underwater Survey Profiles for Transects +8.5, +5.5, and +2.5

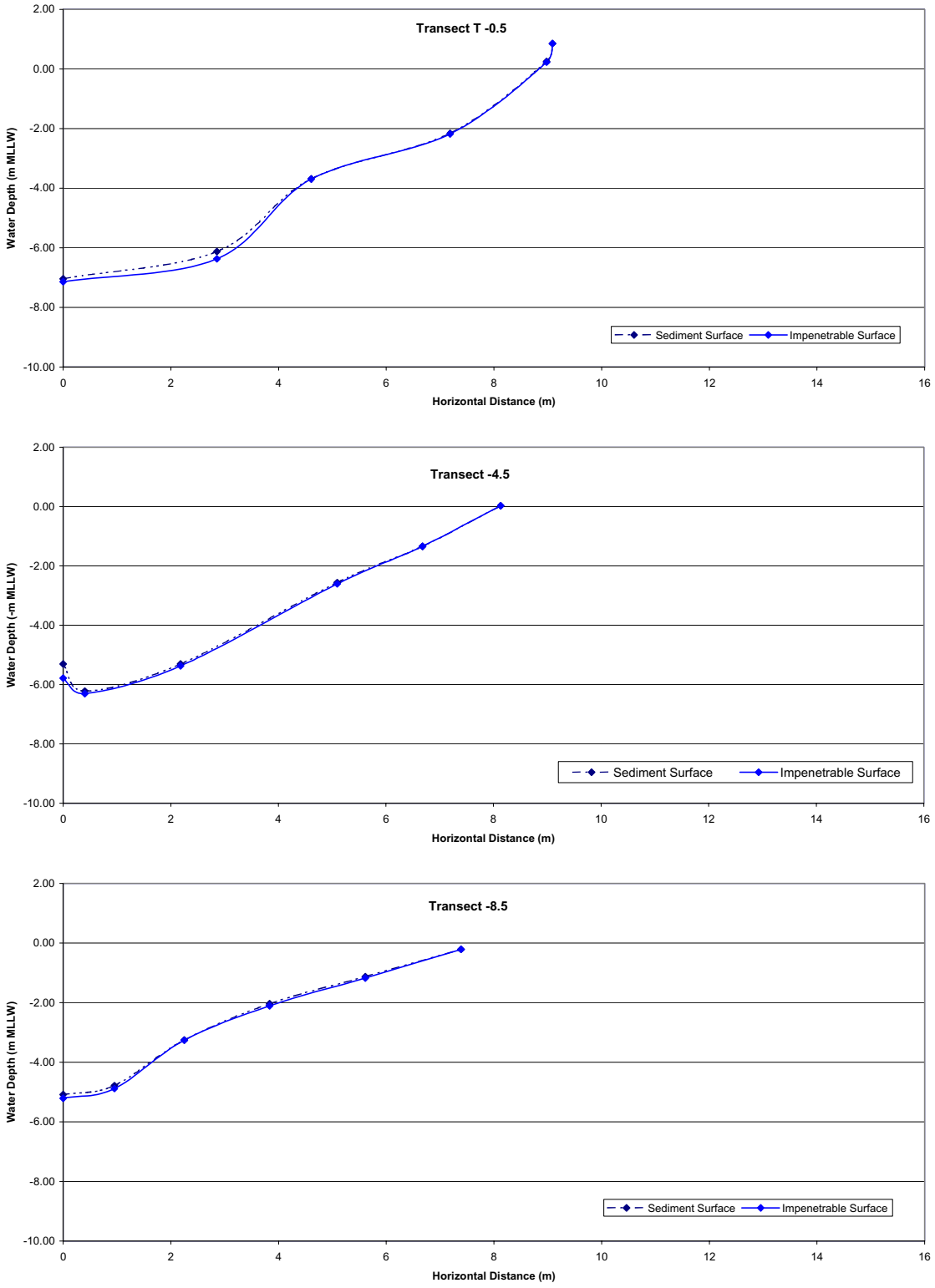
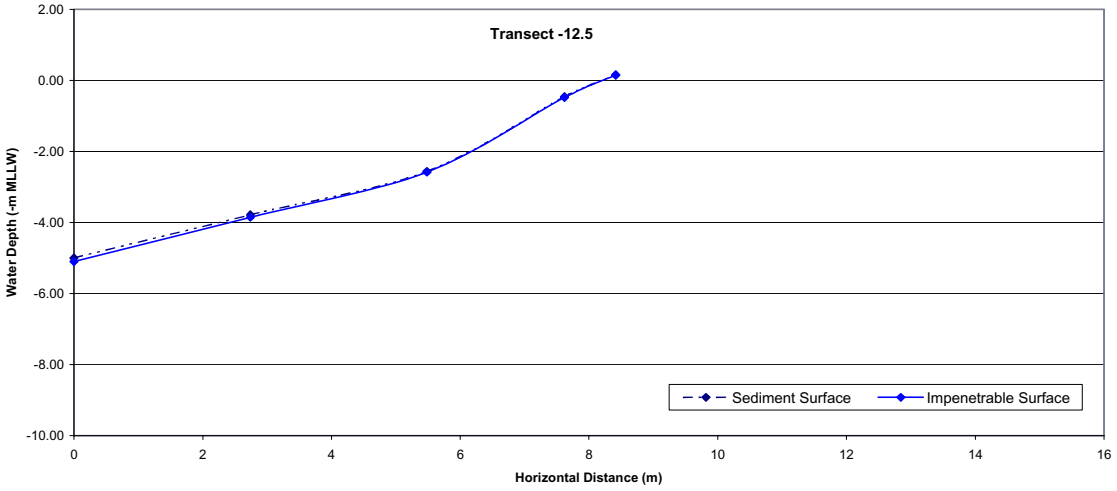
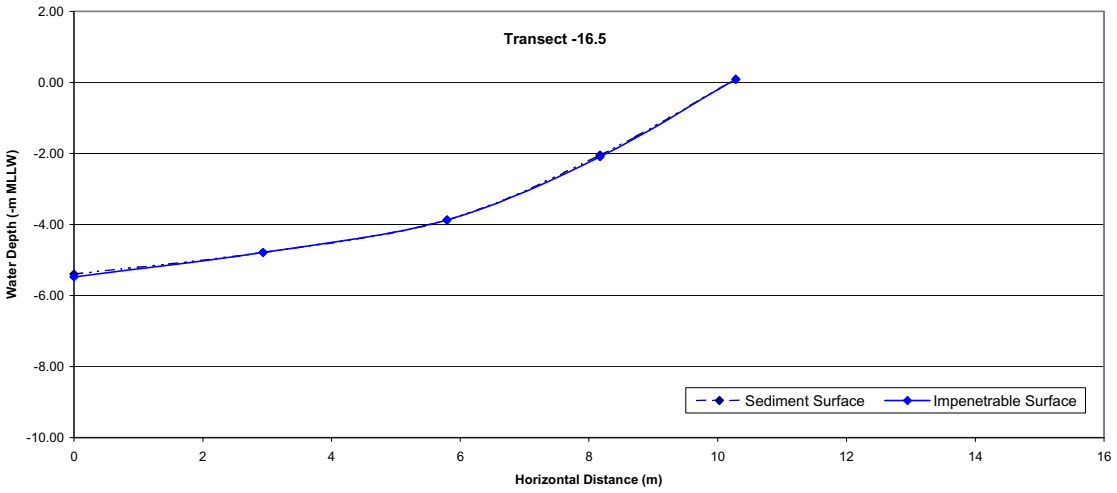


Figure 3-13. Underwater Survey Profiles for Transects -0.5, -4.5, and -8.5





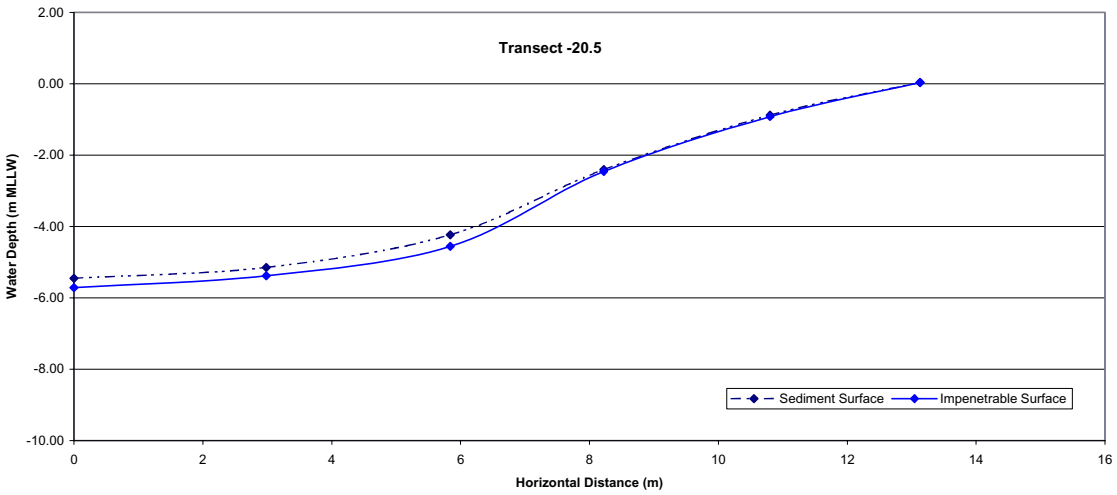


Figure 3-14. Underwater Survey Profiles for Transects -12.5, -16.5, and -20.5

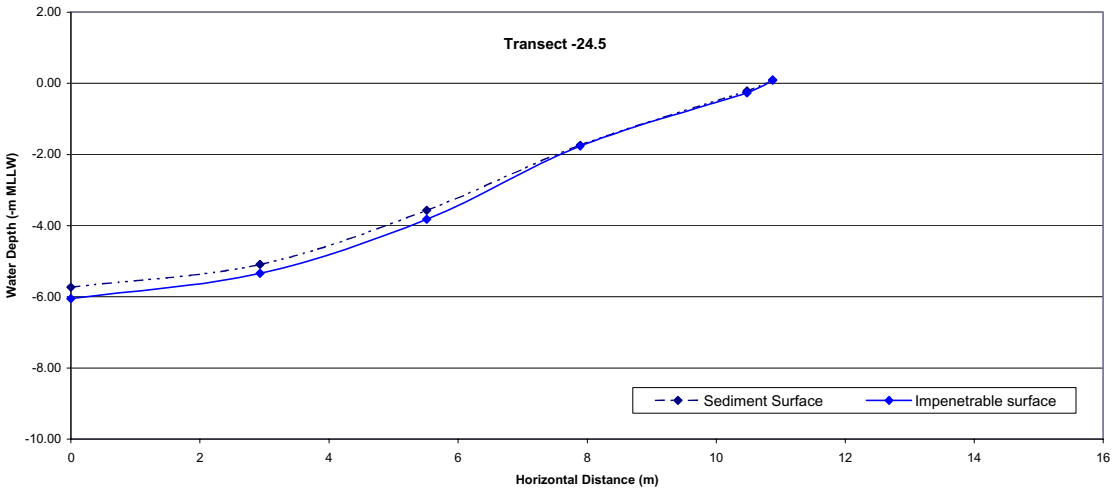


Figure 3-15. Underwater Survey Profile for Transect –24.5

The exposed shoreline tended to be primarily cobbles and various fill material overlying the excavated clay bank. Several types of vertical support or retaining walls occur along the east bank of Lauritzen Channel. There is a continuous vertical wall from the north end (approximately 20 south of the municipal outfall) south to Transect -8.5 (Figures 3-2a, 3-2b, and 3-**16**). The wall does not appear to penetrate or extend below the channel sediment surface; sediment below the wall is generally sandier with smaller cobbles and boulders than occur further south on the channel bank. The northern vertical wall ends with a concrete section near Transect -8.5 (Figure 3-16b). This transect is just north of a major section of upland excavation; it is also where the broken concrete pipe was observed discharging water into Lauritzen Canal. From here to the Levin pier, about 75 m south, the steep clay bank covered with variously sized boulders, cobbles, and debris leads up to the supports for the railroad tracks above (Figure 3-16c,d). Beneath the Levin Pier, vertical supports were often backed by a solid sheet wall, but occasionally there were discontinuities where blocks of fill material were visible behind the vertical supports, or where no vertical support was visible (Figure 3-17).

Figure 3-16. Exposed Shoreline North of Levin Pier, Lauritzen Channel East Bank

(a) Cobbles and debris at bulkhead, Transect +2.5

(b) Deteriorating bulkhead, approximately Transect +7.5

(c) Transition from solid wall to vertical bars holding blocks (~1 ft cubes) of fill material, Transect +26.5

(d) Discontinuity in retaining wall, visible remnants of vertical supports and fill, about Transect +29.5

(e) Blocks of fill below vertical wall, approximately Transect +43.5

(f) Concrete retaining wall south of Transect +67.5, on corner between Levin Berths A and B

Figure 3-17. Exposed Shoreline Beneath Levin Pier, Lauritzen Channel East Bank

3.2.2 Soft Channel Sediment and Embankment Soil Chemistry

Sample collection information for embankment soil and channel sediment samples is provided in Table 3.5 for samples collected in March 2002, immediately following the east bank underwater survey. After reviewing preliminary chemistry from the March samples, EPA collected 21 additional sediment samples in July 2002 at locations that attempted to bound the areas of highest DDT contamination in the east bank of Lauritzen Channel (Table 3.6, narrative in Appendix B). All sampling locations are shown in Figure 2-4.

Table 3.5. Sample Collection Information for March 2002 Sediment and Bank Samples

Sample ID	Date	Station (Transect)	Distance from Baseline (m)	Depth (ft)	Remarks
T(+55.5)C1	3/14/2002	+55.5	6	23	
T(+39.5)C1	3/14/2002	+39.5	3	28	
T(+31.5)B	3/14/2002	+31.5	NA	NA	Sample taken ~6-7 ft above water line at 1535, from between scrap metal and boulders at base of iron bars supporting riprap bank.
T(+23.5)C1	3/14/2002	+23.5	3	30	
T(+2.5)C1	3/14/2002	+2.5	0	28	
T(+2.5)B	3/14/2002	+2.5	NA	NA	Sample taken 3-3.5 ft above water line at 1555 in fill material (cobbles, gravel, boulders) on geotextile fabric.
T(+11.5)C1	3/14/2002	+11.5	0.5	27	
T(+11.5)B	3/14/2002	+11.5	NA	NA	Sample take ~4 ft vertical above water line at 1523.
T(-0.5)C1	3/13/2002	-0.5	approx. 1	25	
T(-0.5)B	3/14/2002	-0.5	NA	NA	Sample of sandy clay fill between boulders, about 6 ft above water line at 1710.
T(-4.5)C1	3/14/2002	-4.5	0.5	23	
T(-4.5)B	3/14/2002	-4.5	NA	NA	Sample of "bank fill" collected between cobbles at base of sheetpile under aluminum ramp.
T(-12.5)C1	3/14/2002	-12.5	0.5	21	Sediment sampled from soft spots between rocks; core pushed in twice to obtain adequate sample volume.
T(-12.5)B	3/14/2002	-12.5	NA	NA	Dry bank material just underneath cap, 10-12 ft above water line at 1604.
T(-19.5)B	3/14/2002	-19.5	NA	NA	Push-cored horizontally into bank instead of using disposable scoop. Substitute for T –20.5; sheetpile obstructed access.
T(-24.5)C1	3/14/2002	-24.5	3	21	
T(-32.5)B	3/14/2002	-32.5	NA	NA	2 ft above water line.

Table 3.6. Sample Collection Information for July 2002 Sediment Samples

Sample ID	Date	Station (Transect)	Distance Offshore of Vertical Wall (ft)	Depth	Remarks
0702S1	07/16/2002	- 4.5	10 ft.	13 ft.	mixture of YBM and OBM
0702S2-O	07/16/2002	-4.5	20 ft.	22 ft.	OBM
0702S2-Y	07/16/2002	-4.5	20 ft.	22 ft.	YBM (4 in. YBM over 0702S2-O)
0702S3	07/16/2002	-2.5	10 ft.	14 ft.	OBM at top of ~5 ft. vertical
0702S4	07/16/2002	-2.5	20 ft.	25 ft.	4 in. YBM over OBM
0702S5	07/16/2002	10.5	10 ft.	13 ft.	sandy YBM and OBM
0702S6	07/16/2002	10.5	20 ft.	23 ft.	
0702S7	07/16/2002	8.5	10 ft.	7 ft.	OBM w/rocks
0702S8	07/16/2002	8.5	20 ft.	23 ft.	YBM w/rocks
0702S8A	07/17/2002	6.5	10 ft.	6 ft.	OBM
0702S9	07/17/2002	6.5	20 ft.	20 ft.	YBM w/grit
0702S10	07/17/2002	4.5	10 ft.	9 ft.	mostly OBM
0702S11	07/17/2002	4.5	20 ft.	20 ft.	YBM w/rocks
0702S12	07/17/2002	3.5	20 ft.	17 ft.	YBM and OBM w/rocks
0702S13	07/17/2002	2.5	10 ft.	10 ft.	
0702S14	07/17/2002	2.5	20 ft.	16 ft.	very rocky, difficult to collect
0702S15	07/17/2002	2	20 ft.	19 ft.	YBM w/pebbles and grit
0702S16	07/17/2002	2	10 ft.	8 ft.	OBM gray/brown
0702S17	07/17/2002	1.5	20 ft.	13 ft.	primarily sand
0702S18	07/17/2002	1.5	20 ft.	13 ft.	duplicate of 0702S17
0702S19	07/17/2002	8.5	0 ft.	4 ft. bgs	light-colored embankment soil

The EPA Region IX Laboratory in Richmond, California, conducted all chemical analyses of pesticides in sediment. Copies of the analytical chemistry data reports provided by Region IX Laboratory are provided in Appendix C. Pesticide concentrations in soil samples collected in March from the east embankment and soft sediment from the bottom of Lauritzen Channel are summarized in Tables 3.7 and 3.8 respectively. Pesticide concentrations in the July sediment samples are provided in Table 3.9. Total DDT concentrations were between 213, 600 and 370,000 µg/kg dry weight (214 to 370 mg/kg or ppm) in three embankment soil samples collected near the north end of the Levin Pier at Transect +2.5 under the pier and Transects –4.5 and –12.5 just north of the pier (Figure 3-6). Continued erosion of these bank soils into the channel is probably one of the sources of DDT to channel sediment.

Table 3.7. Chlorinated Pesticide Concentrations in Lauritzen Channel East Bank Soils

Station ID	Chlorinated Pesticides in Bank Sediment Samples (µg/kg dry weight)							
	T(+31.5)B	T(+11.5)B	T(+2.5)B	T(-0.5)B	T(-4.5)B	T(-12.5)B	T(-19.5)B	T(-32.5)B
DDT and Dieldrin								
2,4'-DDE	80 N[a]	60	3,000	2,000	9,000	16,000	200 N	2,000
4,4'-DDE	30 N	80	600 J	200	2,000	4,000	20 JN	400
2,4'-DDD	280	3,000	30,000	7,000	46,000	50,000	70 N	7,000
4,4'-DDD	200	200	7,000	3,000	20,000	30,000	1,000	3,000
2,4'-DDT	230	2,000	13,000	3,000	20,000	30,000	100	8,000
4,4'-DDT	2,000 J	27,000	160,000	31,000	220,000	240,000	400 N	33,000
Total DDT[b]	**2,820**	**32,340**	**213,600**	**46,200**	**317,000**	**370,000**	**1,790**	**53,400**
Dieldrin	**50 N**	**20 N**	**1,000 J**	**2,000**	**12,000**	**14,000**	**200**	**6,000**
Other Pesticides								
a-BHC	--- [c]	---	20	8 J	5 J	7 J	---	---
g-BHC	---	---	10	---	5 J	10 J	---	---
b-BHC	10 J	---	20 J	20 N	100	200	---	---
d-BHC	---	---	7 J	5 JN	10	30 N	---	---
Heptachlor	---	---	20 B	60 B	320	700	20 B	50 B
Heptachlor epoxide	6 J	---	---	---	50 N	100 N	---	---
g-Chlordane	30	---	100 N	80 N	2,000	2,000	20 JN	460
a-Chlordane	20 N	---	80 N	70 N	1,000 N	1,000 N	20 JN	200 N
Aldrin	---	---	20	20	500	2,000	10 JN	60
Endrin	200 J	20 J	50 N	60 N	2,900	9,000	40 J	3,000
Endrin ketone	50	---	20 N	20 N	200	2,000	40 N	3,600
Endrin aldehyde	---	---	---	---	---	---	---	30 JN
Endosulfan I	---	---	---	---	---	---	---	20 JN
Endosulfan II	---	---	---	---	---	---	---	---
Endosulfan sulfate	---	---	---	---	---	---	---	---
Methoxychlor	---	---	---	---	---	300 N	---	---

(e) Qualifiers are defined as follows:
N Estimated value: sample matrix interference indicated by >40% difference between concentrations of analyte on two columns; presence of analyte deemed presumptive.
J Estimated value: below quantitation limit but greater than or equal to ½ the quantitation limit.
B Estimated value: during calibration verification, difference between columns exceeded QC limit.

(f) Total DDT is sum of detected 2,4'-DDD, 4,4'-DDD, 2,4'-DDE, 4,4'-DDD, 2,4'-DDT, and 4,4'-DDT.

(g) --- None detected.

Table 3.8. Chlorinated Pesticide Concentrations in Lauritzen Channel Soft Sediment Cores

	Chlorinated Pesticides in Soft Sediment Core Samples (µg/kg dry weight)								
Station ID	T(+55.5)C1	T(+39.5)C1	T(+23.5)C1	T(+11.5)C1	T(+2.5)C1	T(-0.5)C1	T(-4.5)C1	T(-12.5)C1	T(-24.5)C1
DDT and Dieldrin									
2,4'-DDE	200 C[a]	80 JC	60 JC	480	150,000	1,000 C	1,000	300	40 CN
4,4'-DDE	50	30 C	20 JC	40 N	10,000	30 C	80 N	20 J	370
2,4'-DDD	20 CN	200 C	60 C	2,000	3,000,000	800 C	1,000	800	1,000
4,4'-DDD	1,100 C	320 C	200 C	2,000	900,000	3,500	3,000	1,000	4,300
2,4'-DDT	200 C	60 C	60 C	350	130,000	200	600	100	200 CN
4,4'-DDT	200 JC	2,000 C	860 C	12,000	19,000,000	5,200	4,700	3,700	3,000
Total DDT[b]	**1,770**	**2,690**	**1,260**	**16,870**	**23,190,000**	**10,730**	**10,380**	**5,920**	**8,910**
Dieldrin	**60 C**	**20**	**20**	**90**	**50,000**	**200**	**800**	**70**	**8,070 C**
Other Pesticides									
a-BHC	--- [c]	---	---	---	500	---	---	---	---
g-BHC	---	---	---	---	30	---	---	---	---
b-BHC	40 CN	---	---	20 N	40	---	---	---	40
d-BHC	---	---	---	---	200	10 C	---	---	---
Heptachlor	---	---	---	---	80	---	---	---	---
Heptachlor epoxide	---	---	---	---	---	---	---	---	---
g-Chlordane	---	---	---	---	300 N	30 C	50 N	7 JN	60
a-Chlordane	10 JCN	---	---	---	300 N	20 J	40 N	---	20
Aldrin	---	---	---	---	8,000	20 C	50	20	---
Endrin	---	---	---	---	1,000	40 CN	40	---	---
Endrin ketone	---	---	---	---	1,000	---	---	---	---
Endrin aldehyde	---	---	---	---	200	---	---	---	---
Endosulfan I	---	---	---	---	---	---	---	---	---
Endosulfan II	---	---	---	---	4,000 N	---	---	---	---
Endosulfan sulfate	---	---	---	---	---	---	---	---	---
Methoxychlor	---	---	---	---	---	---	---	---	---

(h) Qualifiers are defined as follows:
C Associated surrogate recovery did not meet QC limits.
J Estimated value: below quantitation limit but greater than or equal to ½ the quantitation limit.
N Estimated value: sample matrix interference indicated by >40% difference between concentrations of analyte on two columns; presence of analyte deemed presumptive.

(i) Total DDT is sum of detected 2,4'-DDD, 4,4'-DDD, 2,4'-DDE, 4,4'-DDD, 2,4'-DDT, and 4,4'-DDT.

(j) --- None detected.

Table 3.9. DDT and Dieldrin Concentrations in Additional Lauritzen Channel Sediment Samples Collected by EPA in July 2002

	Chlorinated Pesticides in Sediment Core Samples (µg/kg dry weight)							
Station ID	2,4'-DDE	4,4'-DDE	2,4'-DDD	4,4'-DDD	2,4'-DDT	4,4'-DDT	**Total DDT[a]**	**Dieldrin**
0702-S1 (T -4.5)	40 U[N]	40 U	60	100	40	600	800	20 JC
0702-S2-OBM[c]	20 U	20 U	10 U	20	20 U	30	50	20 U
0702-S2-YBM[c]	300 U	300 U	200 JC	500	300 U	2500	3000	300 U
0702-S3 (T –2.5)	20 U	20	60	100	120	320	620	10 JC
0702-S4 (T –2.5)	4000 U	4000 U	3000 JC	9000	22000	110000	144000	3000 JC
0702-S17 (T +1.5)	2000 U	2000 U	1000 JC	3000	4000	17000	25000	1000 U
0702-S18 (T +1.5)	200 U	200	1200	1400	2600	8000	13400	300
0702-S15 (T +2.0)	300 U	300 U	400 JN	1100 JN	800 JN	6000 JN	8300	300 U
0702-S16 (T +2.0)	200 U	100 JC	300	1400	900	11000	13700	200 U
0702-S13 (T +2.5)	200 U	200	300	900	3600	12000	17000	200 U
0702-S14 (T +2.5)	600	10000	10000	60000	110000	1400000 JE	1590600	6500
0702-S12 (T +3.5)	200	2400	8700	12000	20000	120000	163300	1400
0702-S10 (T +4.5)	20 U	20	30	60	60	310	480	20 U
0702-S11 (T +4.5)	200 U	600 JN	1600 JN	5000 JN	2200 JN	25000 JNE	34400	400 JN
0702-S8A (T +6.5)	50 U	50 U	50 U	90	140	600	830	50 U
0702-S9 (T +6.5)	3000 U	3000 U	2000 J	5000	3000	29000	39000	2000 U
0702-S7 (T +8.5)	300 U	300	200 JC	400	500	2100	3500	300 U
0702-S8 (T +8.5)	300 U	400 JN	800 JN	2600 JN	1000 JN	29000 JN	33800	300 U
0702-S19[d] bank (T +8.5)	2000 U	2000	2000 U	2000 U	4000	29000	39000	1000 U
0702-S5 (T +10.5)	300 U	300	200 JC	600	300	2200	3600	300 U
0702-S6 (T +10.5)	300 U	500 JN	700 JN	2300 JN	1400 JN	10000 JN	14900	200 JCN

(a) Total DDT is sum of detected 2,4'-DDD, 4,4'-DDD, 2,4'-DDE, 4,4'-DDD, 2,4'-DDT, and 4,4'-DDT.

(b) Qualifiers are defined as follows:
U Undetected above given concentration.
J Estimated value: below quantitation limit but greater than or equal to ½ the quantitation limit.
C Associated surrogate recovery did not meet QC limits.
N Estimated value: sample matrix interference indicated by >40% difference between concentrations of analyte on two columns; presence of analyte deemed presumptive.
E Estimated value: amount detected exceeds calibration range of instrument.

(c) 0702-S2-OBM and 0702-S2-YBM are Older Bay Mud (firm, consolidated clay) and overlying Younger Bay Mud (unconsolidated soft sediment) collected 20 ft offshore of the vertical bulkhead at Transect –4.5.

(d) 0702-19 is a bank soil sample collected from Transect +8.5, approximately 4 ft below ground surface. All other 0702-samples are soft sediment cores.

Where core and bank samples were collected in the same transect, channel sediment concentrations were generally lower than (less than half) the corresponding bank sample. The obvious exception was the sediment cores from Transect +2.5, where the DDT concentration was much higher (100x) in the channel than that of the embankment sample from the same transect (Tables 3.7 through 3-9, Figures 3-18 and 3-19). Sediment core sample T(+2.5)C1 contained the highest concentration of DDT measured in the channel since remediation, 23,190,000 µg/kg (23,190 mg/kg or ppm; 23 parts per thousand). EPA's July sample 0702-S14, collected shoreward (upslope) of T(+2.5)C1, also had a very high concentration of total DDT with 1,590,600 (1,591 mg/kg or ppm; 1.6 parts per thousand). Dieldrin concentrations were also relatively high in T(+2.5)C1, as well as in bank samples from Transects -4.5 and -12.5 (Tables 3.7 through 3-9, Figures 3-20 and 3-21).

Transect +2.5 sediment and bank samples, together with samples from Transects -4.5 and -12.5, provide convincing evidence that undredged sediment under the pier and unexcavated upland bank soil are present at high enough levels of pesticides to contribute significantly to the sediment contamination observed in the channel off the north end of Levin Pier during the 1999 Sediment Investigation (Figure 1-3). Both the 1999 Sediment Investigation and the present study (samples 0702-S2-OBM and 0702-8A) confirmed that the underlying consolidated clays of the Older Bay Mud formation are uncontaminated, and represent a barrier to downward migration of pesticides in sediment. DDT contamination in Lauritzen Channel remains limited to the unconsolidated channel sediment, but eroding banks could be contributing unconsolidated sediment to the channel.

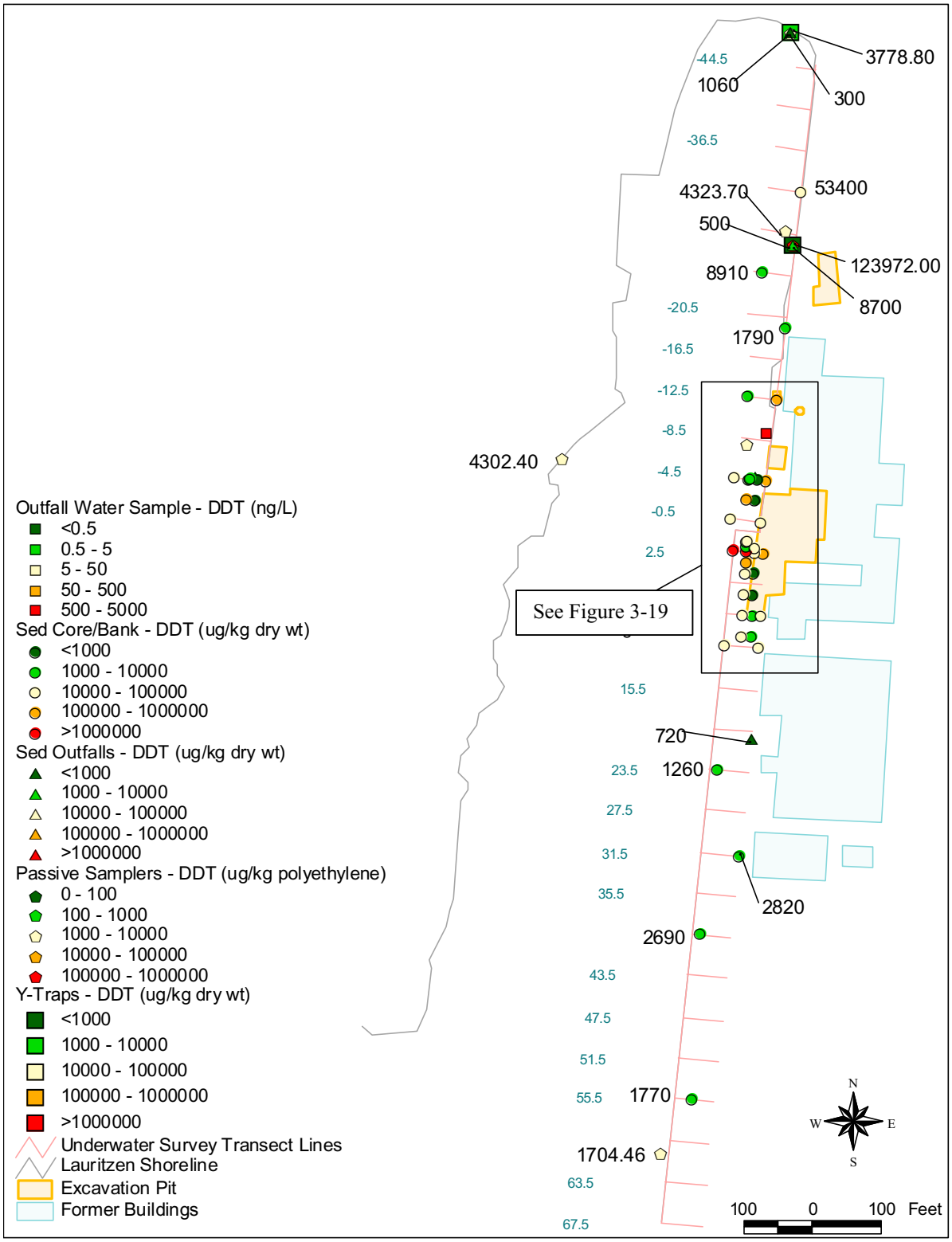


Figure 3-18. DDT Concentrations in Sediment Core and Embankment Soil Samples Throughout Lauritzen Channel

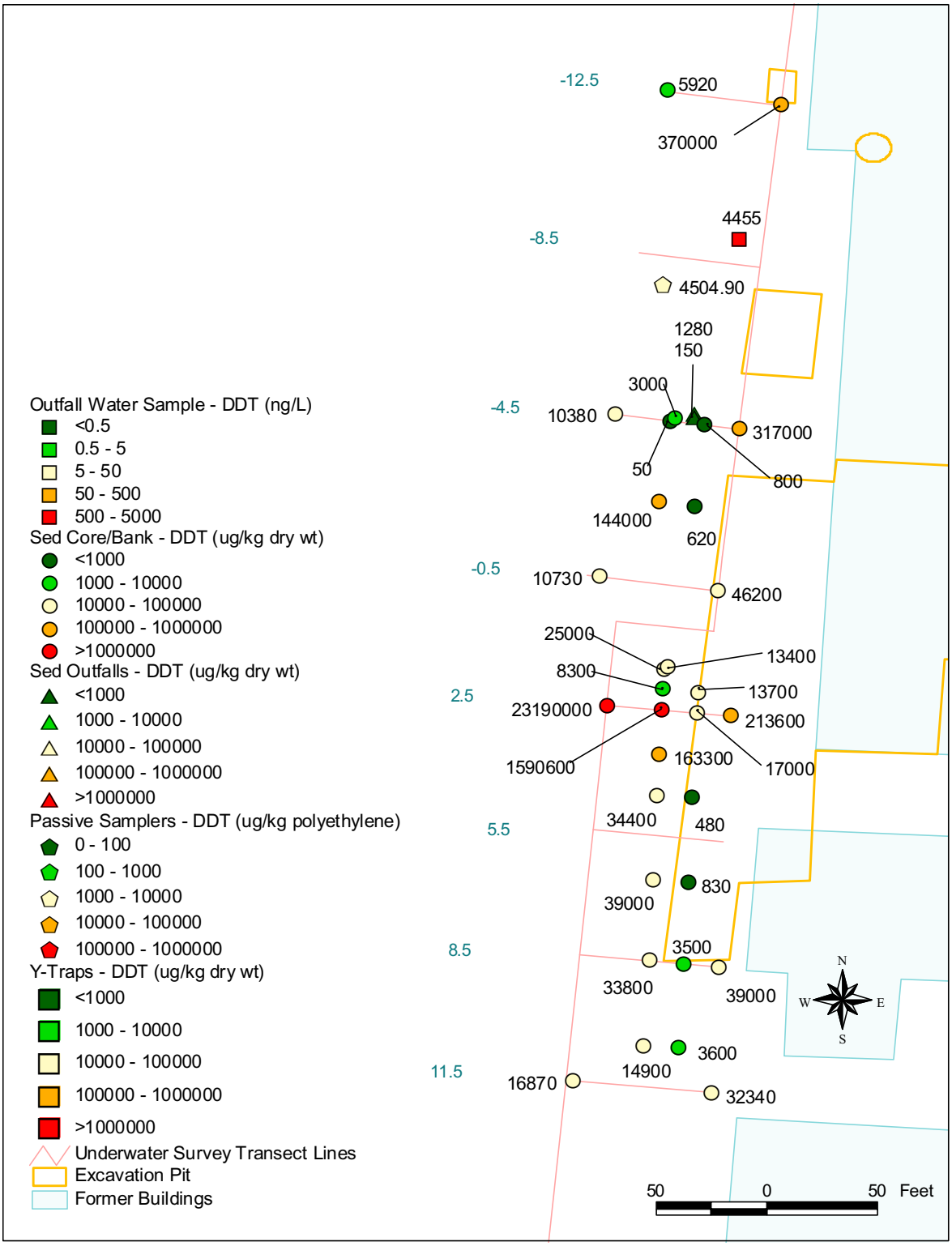


Figure 3-19. DDT Concentrations in Sediment Core and Embankment Soil Samples Concentrated in North Central Lauritzen Channel

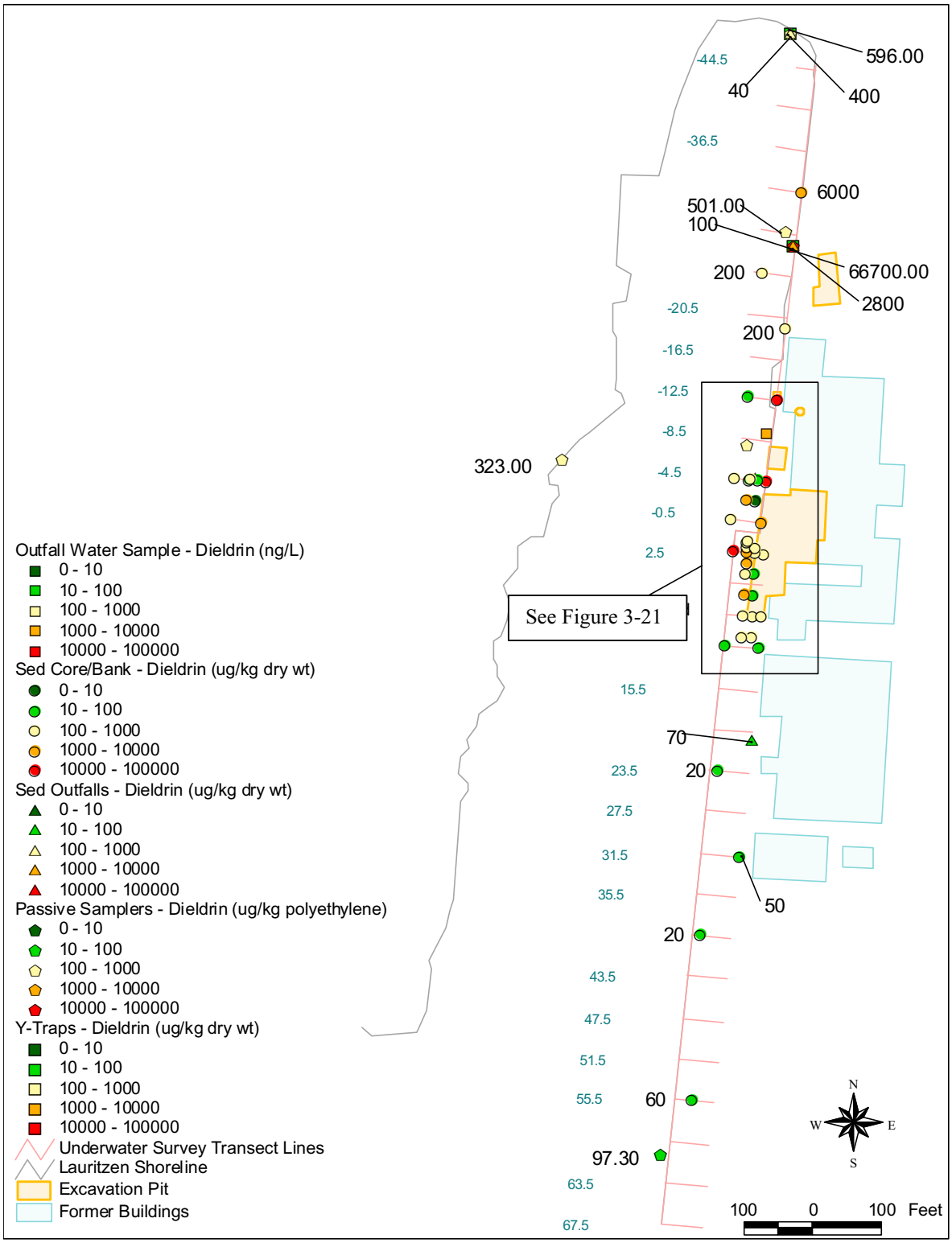


Figure 3-20. Dieldrin Concentrations in Sediment Core and Embankment Soil Samples Throughout Lauritzen Channel

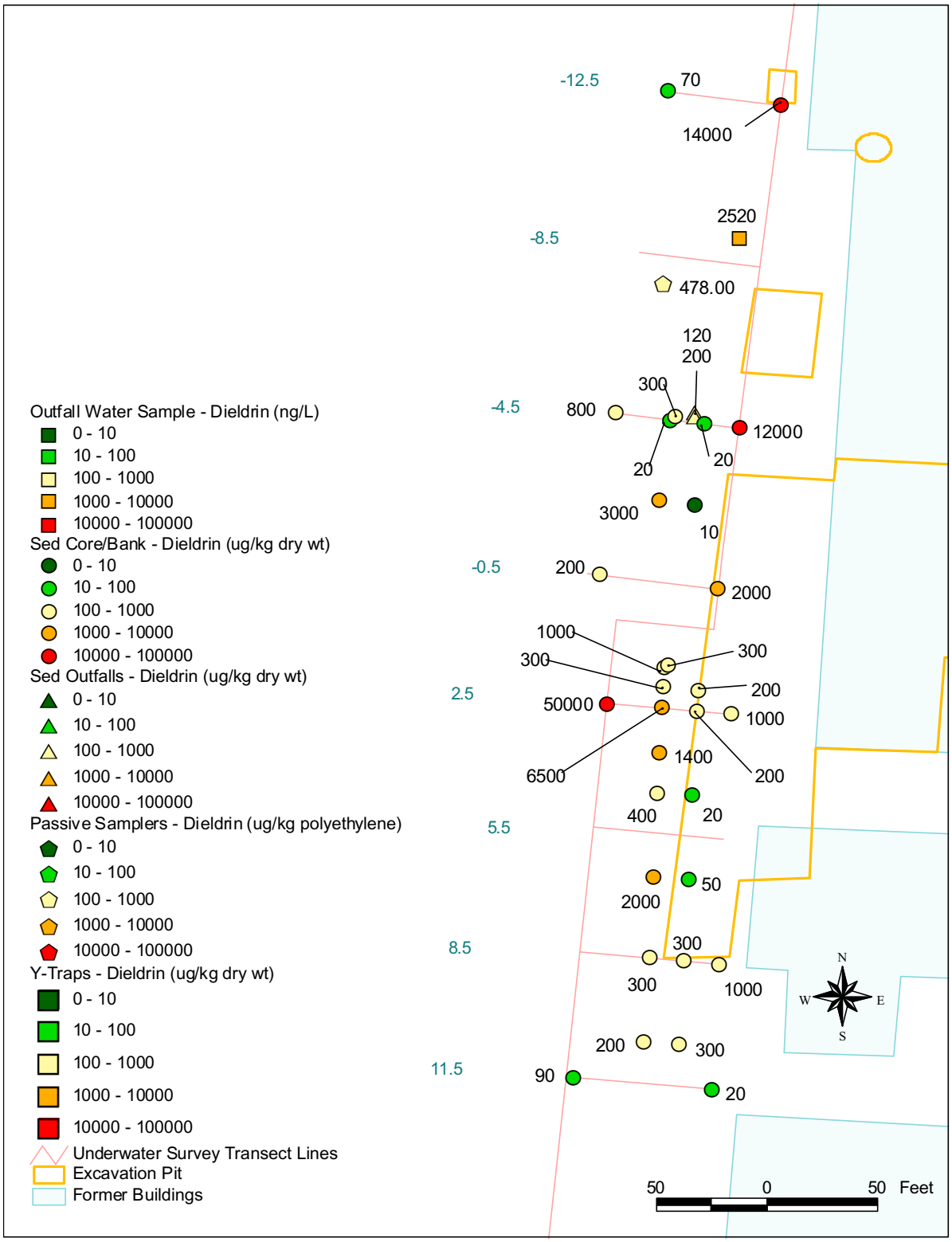


Figure 3-21. Dieldrin Concentrations in Sediment Core and Embankment Soil Samples Concentrated in North Central Lauritzen Channel

4.0 CONCLUSIONS

The Phase I Source Investigation objectives were to identify potential upland contaminant sources with an outfall pathway to Lauritzen Channel, and identify locations where unexcavated bank material or undredged channel sediment were contributing to the high DDT levels found during the 1999 Sediment Investigation. Most of the identified outfalls are not considered significant sources of the DDT sediment contamination in Lauritzen Channel, but two of the outfalls bear further investigation:

- Concrete outfall found near Transect -8.5: This outfall was discovered discharging a small volume of water during the March sampling. A grab sample of the discharge water contained part-per-million levels of total DDT and dieldrin, almost 250 times the bulk water sample for the nearest annual monitoring station (303.3, Lauritzen Channel/End) and three orders of magnitude higher than bulk water from the Lauritzen Channel/Mouth monitoring station. This outfall represents a connection between the upland and marine portions of the Heckathorn site, and the observed active discharge of water more contaminated than the receiving water indicates that this outfall is a source of pesticides to Lauritzen Channel water and sediment. However, the drain field for the outfall, the frequency of discharge, and volume of discharge are all unknown.

- The 8-in outfall near Transect –27: This outfall is recommended for further investigation because the results obtained in Phase I neither confirm nor deny that it is a source of DDT to the channel. DDT was present in the grab sample and the passive water sampler associated with this pipe, but the DDT concentration in sediment caught in the Y-trap was below the remediation goal. The pipe discharge point is submerged at high tide, and it is unknown whether the pipe collects water or sediment from the upland part of the site or whether the observed flow (drip) when the Y-trap was installed was actual discharge or just channel water dripping after the ebb tide. This pipe has been observed at other times with no discharge flowing or dripping from it. Like the concrete outfall, the frequency and volume of discharge and the drainage area are unknown for the 8-in. pipe.

Upland contaminant sources with a pathway to the channel via the channel banks were also considered during the Phase I Source Investigation. Bank soil samples were collected in locations identified by the RPM based on the locations of former buildings on the site and the limit of prior upland excavations. Soil samples collected from the channel bank at Transects +2.5, -4.5, -8.5, and -12.5 all contained higher concentrations of DDT than those previously found in channel sediments (Kohn and Gilmore 2000), confirming that upland soils at the north end of the Levin Pier could be contributing to channel sediment contamination via erosion. Although the extent of upland soils that were previously excavated during removal action is known, the extent of contamination in unexcavated areas is not known. Terrestrial sampling conducted after soil removal action showed that average concentrations on the site were below the upland remedial goal concentration at the time. However, the Phase I Source Investigation indicates that the extent of terrestrial bank soil contamination warrants further investigation.

Undredged sediment from beneath the Levin Pier has been a suspected contaminant source to the rest of the channel since recontamination was first documented (Antrim and Kohn 2000b). Although the volume of soft sediment along the east bank was confirmed to be relatively small, less than 1000 cy, two of the cores from Transect +2.5 had the highest DDT concentrations found in Lauritzen Channel sediment (23,190,000 µg/kg or 23,190 ppm, and 1,590,600 µg/kg or 1,591 ppm). This is one to two orders of magnitude higher than the highest concentrations found in surface sediment during the 1999 Sediment Investigation, and provides strong evidence for redistribution of undredged sediment from under the pier as a source of DDT contamination to the main part of Lauritzen Channel. Levin Berths B and C are particularly vulnerable to accumulation of contaminated sediment because they are deep and less subject to disturbance

The Phase I Source Investigation was successful in identifying significant sources of DDT contamination to Lauritzen Channel sediment. Undredged sediment under the Levin pier that has been redistributed to the channel was identified as the likely source for some of the very high DDT concentrations in channel sediment. Because of the vessel activity in Lauritzen Channel, sediment is frequently resuspended and deposited in different parts of the channel, and the potential for transport out of the channel continues to be a concern. However, the volume of soft sediment and range of DDT concentrations in the channel are relatively well-defined. What is not well-defined is the contribution of bank material in the north central section of Lauritzen Channel's East Bank. This material contains high concentrations of DDT and has a direct erosional pathway to the channel. In addition, upland material may be leaching DDT into subsurface water that reaches the channel via the concrete outfall near Transect –8.5. The identification of potential continuing upland sources of DDT to channel sediments warrants further investigation.

5.0 REFERENCES

Anderson. B. S., J. W. Hunt, B. M. Phillips, M. Stoelting, J. Becker, R. Fairey, H. M. Puckett, M. Stephenson, R. S. Tjeerdema, and M. Martin. 2000. "Ecotoxicologic Change at a Remediated Superfund Site in San Francisco, California, USA." *Environmental Toxicology and Chemistry* 19(4): 879-887.

Antrim, L.D., and N.P. Kohn. 2000a. *Post-remediation Biomonitoring of Pesticides in Marine Waters Near the United Heckathorn Site, Richmond, California*. PNNL-11911, Rev. 1. Prepared for the U.S. Environmental Protection Agency by Battelle Marine Sciences Laboratory, Sequim Washington; published by Pacific Northwest National Laboratory, Richland, Washington.

Antrim, L.D., and N.P. Kohn. 2000b. *Post-remediation Biomonitoring of Pesticides and Other Contaminants in Marine Waters and Sediment Near the United Heckathorn Site, Richmond, California*. PNNL-13059, Rev 1. Prepared for the U.S. Environmental Protection Agency by Battelle Marine Sciences Laboratory, Sequim Washington; published by Pacific Northwest National Laboratory, Richland, Washington.

Battelle. 2002. "Sampling and Analysis Plan: Investigation of Contaminant Source and Contaminant Movement in Lauritzen Channel, Heckathorn Superfund Site, Richmond, California." February 2002. Prepared for U.S. Environmental Protection Agency, Region 9, San Francisco, California. Battelle Marine Sciences Laboratory, Sequim, Washington.

EPA (U. S. Environmental Protection Agency). 1998. "Method 8081b Organochlorine Pesticides by Gas Chromatography (Revision 2, January 1998)." In *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods*. SW-846. U.S. Document No. 955-001-00000, U. S. Environmental Protection Agency, Washington, D.C.

Kohn, N. P., and T. J. Gilmore. 2001. *Field Investigation to Determine the Extent of Sediment Recontamination at the United Heckathorn Superfund Site, Richmond, California*. PNNL-13730. Prepared for the U.S. Environmental Protection Agency by Battelle Marine Sciences Laboratory, Sequim Washington; published by Pacific Northwest National Laboratory, Richland, Washington.

Kohn, N. P., and R. K. Kropp. 2001a. *Year 3 Post-Remediation Monitoring of Pesticides and Other Contaminants in Marine Waters Near the United Heckathorn Superfund Site, Richmond, California*. PNNL-13286. Prepared for the U.S. Environmental Protection Agency by Battelle Marine Sciences Laboratory, Sequim Washington; published by Pacific Northwest National Laboratory, Richland, Washington.

Kohn, N. P., and R. K. Kropp. 2001b. *Year 4 Post-Remediation Monitoring of Pesticides and Other Contaminants in Marine Waters Near the United Heckathorn Superfund Site, Richmond, California*. PNNL-13632. Prepared for the U.S. Environmental Protection Agency by Battelle Marine Sciences Laboratory, Sequim Washington; published by Pacific Northwest National Laboratory, Richland, Washington.

Kohn, N. P., and R. K. Kropp. 2002. *Year 5 Post-Remediation Biomonitoring of Pesticides and Other Contaminants in Marine Waters Near the United Heckathorn Superfund Site, Richmond, California*. PNNL-13990. Prepared for the U. S. Environmental Protection Agency by Battelle Marine Sciences Laboratory, Sequim, Washington; published by Pacific Northwest National Laboratory, Richland, Washington.

LRTC (Levin Richmond Terminal Corporation). 2001. *Year 2000-2001 Report Documenting the Implementation of the Operations and Maintenance Plan [for the] Former Heckathorn NPL Site Located at the Levin Richmond Terminal Corporation, 402 Wright Avenue, Richmond, California*. October 2001. Report submitted to EPA by Levin Richmond Terminal Corporation, Richmond, California.

APPENDIX A

PRECIPITATION MONITORING
DURING OUTFALL SAMPLER DEPLOYMENT

Precipitation Data for Richmond, CA

(2/6/2002 to 3/14/2002)

Procedure:

Passive water samplers were deployed at the mouths of several outfall pipes in the Lauritzen Channel on February 6, 2002 as part of a field investigation to determine the current source of pesticide contamination in the sediment of the channel. Samplers were retrieved from the outfalls on March 14, 2002.

As part of this study, precipitation data were collected for Richmond and other Bay Area precipitation data locations. Both daily (tipping bucket) and event precipitation data were collected. The data were retrieved from the National Weather Service Forecast Office for San Francisco Bay Area/Monterey website and the California Department of Water Resources website.

The daily precipitation data were retrieved directly from the National Weather Service website for the precipitation station called "RICC1," located at the Richmond Wastewater Plant at 601 Canal Blvd. in Richmond, CA. This station is approximately 1/2 mile west of Lauritzen Channel. The RICC1 station does not record storm event data; therefore, several other Bay Area precipitation data stations were consulted for this information: the San Rafael Civic Center station (SFC), located approximately 10-12 miles west/northwest of the Lauritzen Channel, the San Leandro Bay station (SLE), located approximately 15-20 miles south/southeast of the channel, and the Arroyo Corte Madera station (ACM), located approximately 10 miles west of the channel. The event data were collected for these three Bay Area precipitation data stations from the California Department of Water Resources website. The website provides the accumulated rain (inches) data and elapsed time (minutes) data for storm events, from which rainfall intensity (in./hr) was calculated.

Sources:

The National Weather Service Forecast Office for San Francisco Bay Area/Monterey:

http://www.wrh.noaa.gov/Monterey/climate.html

The California Department of Water Resources:

http://cdec.water.ca.gov

Table A.1. Daily Precipitation in Richmond, California, February 6 through March 15, 2002

RICC1: Wastewater Plant, Public Works Dept.
601 Canal Boulevard, Richmond, CA
http://www.wrh.noaa.gov/Monterey/climate.html

Date	High temp (ºF)	Low Temp (ºF)	**RICC1** Elev: 20 ft Precip. (in.)
02/06/2002	58	41	0
02/07/2002	57	51	0.03
02/08/2002	59	42	0.24
02/09/2002	65	40	0
02/10/2002	67	45	0
02/11/2002	65	47	0
02/12/2002	65	46	0
02/13/2002	56	46	0.10
02/14/2002	57	47	0
02/15/2002	58	49	T
02/16/2002	58	50	0
02/17/2002	57	44	0.60
02/18/2002	57	M	M
02/19/2002	55	44	0.33
02/20/2002	62	54	0.03
02/21/2002	69	50	0
02/22/2002	70	54	0
02/23/2002	59	49	0.07
02/24/2002	66	44	0
02/25/2002	72	47	0
02/26/2002	72	51	0
02/27/2002	77	50	0
02/28/2002	71	48	0
03/01/2002	70	50	0
03/02/2002	67	43	0
03/03/2002	69	44	0
03/04/2002	69	44	0
03/05/2002	58	47	0
03/06/2002	57	52	0.37
03/07/2002	55	49	1.02
03/08/2002	57	40	0
03/09/2002	57	41	0
03/10/2002	59	48	0.92
03/11/2002	64	49	0
03/12/2002	62	52	0
03/13/2002	57	45	0
03/14/2002	60	43	0
03/15/2002	60	42	0

Table A.2. Daily Precipitation, Including Rainfall Intensity, at San Rafael Civic Center Station, San Rafael, California, February 6 through March 15, 2002

San Rafael Civic Center – San Rafael (SFC)
Precipitation - Tipping Bucket
http://cdec.water.ca.gov/

Elevation: 120 ft
Lat: 37.998 º N
Long: 122.537 º W

Date	Time		Accumlated Rainfall (in)[a]	Incremental Rainfall (in)	Elapsed Time	Elapsed Time hr.	Elapsed Time min.	Intensity (in/hr)
02/05/2002	10:59:00	AM	6.93	-	-	-	-	
02/06/2002	10:59:00	AM	6.93	0	24:00:00	24	0	0.00
02/07/2002	1:55:00	AM	6.94	0.01	2:56:00	2	56	0.00
02/07/2002	2:50:00	AM	6.95	0.01	0:55:00	0	55	0.01
02/07/2002	10:32:00	AM	6.97	0.02	7:42:00	7	42	0.00
02/07/2002	10:58:00	AM	7.00	0.03	0:26:00	0	26	0.07
02/07/2002	11:09:00	AM	7.01	0.01	0:11:00	0	11	0.05
02/07/2002	11:25:00	AM	7.02	0.01	0:16:00	0	16	0.04
02/07/2002	11:40:00	AM	7.04	0.02	0:15:00	0	15	0.08
02/07/2002	12:18:00	PM	7.05	0.01	0:38:00	0	38	0.02
02/07/2002	1:19:00	PM	7.08	0.03	1:01:00	1	1	0.03
02/07/2002	1:50:00	PM	7.09	0.01	0:31:00	0	31	0.02
02/07/2002	1:56:00	PM	7.10	0.01	0:06:00	0	6	0.10
02/07/2002	3:01:00	PM	7.11	0.01	1:05:00	1	5	0.01
02/07/2002	3:20:00	PM	7.12	0.01	0:19:00	0	19	0.03
02/07/2002	3:32:00	PM	7.13	0.01	0:12:00	0	12	0.05
02/07/2002	3:48:00	PM	7.14	0.01	0:16:00	0	16	0.04
02/07/2002	5:17:00	PM	7.15	0.01	1:29:00	1	29	0.01
02/07/2002	5:22:00	PM	7.16	0.01	0:05:00	0	5	0.12
02/07/2002	5:28:00	PM	7.18	0.02	0:06:00	0	6	0.20
02/07/2002	5:46:00	PM	7.23	0.05	0:18:00	0	18	0.17
02/07/2002	5:54:00	PM	7.25	0.02	0:08:00	0	8	0.15
02/07/2002	5:59:00	PM	7.26	0.01	0:05:00	0	5	0.12
02/07/2002	6:11:00	PM	7.30	0.04	0:12:00	0	12	0.20
02/07/2002	6:21:00	PM	7.32	0.02	0:10:00	0	10	0.12
02/07/2002	6:27:00	PM	7.33	0.01	0:06:00	0	6	0.10
02/07/2002	6:32:00	PM	7.34	0.01	0:05:00	0	5	0.12
02/07/2002	6:36:00	PM	7.35	0.01	0:04:00	0	4	0.15
02/07/2002	6:41:00	PM	7.36	0.01	0:05:00	0	5	0.12
02/07/2002	6:44:00	PM	7.37	0.01	0:03:00	0	3	0.20
02/07/2002	6:50:00	PM	7.38	0.01	0:06:00	0	6	0.10
02/07/2002	6:53:00	PM	7.39	0.01	0:03:00	0	3	0.20
02/07/2002	6:55:00	PM	7.40	0.01	0:02:00	0	2	0.30
02/07/2002	10:59:00	PM	7.40	0	4:04:00	4	4	0
02/08/2002	10:59:00	AM	7.40	0	12:00:00	12	0	0
02/08/2002	10:59:00	PM	7.40	0	12:00:00	12	0	0
02/09/2002	10:59:00	AM	7.40	0	12:00:00	12	0	0
02/09/2002	10:59:00	PM	7.40	0	12:00:00	12	0	0
02/10/2002	10:59:00	AM	7.40	0	12:00:00	12	0	0

Table A.2. (cont'd)

San Rafael Civic Center – San Rafael (SFC)
Precipitation - Tipping Bucket
http://cdec.water.ca.gov/

Elevation: 120 ft
Lat: 37.998 º N
Long: 122.537 º W

Date	Time		Accumlated Rainfall (in)[a]	Incremental Rainfall (in)	Elapsed Time	Elapsed Time hr.	Elapsed Time min.	Intensity (in/hr)
02/10/2002	10:59:00	PM	7.40	0	12:00:00	12	0	0
02/11/2002	10:59:00	AM	7.40	0	12:00:00	12	0	0
02/11/2002	10:59:00	PM	7.40	0	12:00:00	12	0	0
02/12/2002	10:59:00	AM	7.40	0	12:00:00	12	0	0
02/13/2002	10:59:00	AM	7.40	0	24:00:00	24	0	0
02/13/2002	12:12:00	PM	7.41	0.01	1:13:00	1	13	0.01
02/13/2002	2:12:00	PM	7.42	0.01	2:00:00	2	0	0
02/13/2002	2:27:00	PM	7.43	0.01	0:15:00	0	15	0.04
02/13/2002	2:39:00	PM	7.44	0.01	0:12:00	0	12	0.05
02/13/2002	2:51:00	PM	7.45	0.01	0:12:00	0	12	0.05
02/13/2002	3:21:00	PM	7.46	0.01	0:30:00	0	30	0.02
02/13/2002	10:59:00	PM	7.46	0	7:38:00	7	38	0
02/14/2002	10:59:00	PM	7.46	0	24:00:00	24	0	0
02/15/2002	10:59:00	AM	7.46	0	24:00:00	24	0	0
02/16/2002	10:59:00	AM	7.46	0	24:00:00	24	0	0
02/16/2002	4:36:00	PM	7.47	0.01	5:37:00	5	37	0
02/16/2002	4:41:00	PM	7.48	0.01	0:05:00	0	5	0.12
02/16/2002	4:46:00	PM	7.49	0.01	0:05:00	0	5	0.12
02/16/2002	4:51:00	PM	7.50	0.01	0:05:00	0	5	0.12
02/16/2002	4:53:00	PM	7.51	0.01	0:02:00	0	2	0.30
02/16/2002	4:56:00	PM	7.52	0.01	0:03:00	0	3	0.20
02/16/2002	4:58:00	PM	7.53	0.01	0:02:00	0	2	0.30
02/16/2002	5:01:00	PM	7.54	0.01	0:03:00	0	3	0.20
02/16/2002	5:03:00	PM	7.55	0.01	0:02:00	0	2	0.30
02/16/2002	5:06:00	PM	7.56	0.01	0:03:00	0	3	0.20
02/16/2002	5:08:00	PM	7.57	0.01	0:02:00	0	2	0.30
02/16/2002	5:10:00	PM	7.58	0.01	0:02:00	0	2	0.30
02/16/2002	5:11:00	PM	7.59	0.01	0:01:00	0	1	0.60
02/16/2002	5:15:00	PM	7.60	0.01	0:04:00	0	4	0.15
02/16/2002	5:16:00	PM	7.62	0.02	0:01:00	0	1	**1.20**
02/16/2002	5:19:00	PM	7.63	0.01	0:03:00	0	3	0.20
02/16/2002	5:22:00	PM	7.64	0.01	0:03:00	0	3	0.20
02/16/2002	5:26:00	PM	7.65	0.01	0:04:00	0	4	0.15
02/16/2002	5:29:00	PM	7.66	0.01	0:03:00	0	3	0.20
02/16/2002	5:34:00	PM	7.67	0.01	0:05:00	0	5	0.12
02/16/2002	5:35:00	PM	7.68	0.01	0:01:00	0	1	0.60
02/16/2002	5:38:00	PM	7.69	0.01	0:03:00	0	3	0.20
02/16/2002	5:40:00	PM	7.70	0.01	0:02:00	0	2	0.30
02/16/2002	5:43:00	PM	7.71	0.01	0:03:00	0	3	0.20
02/16/2002	5:46:00	PM	7.73	0.02	0:03:00	0	3	0.40

Table A.2. (cont'd)

San Rafael Civic Center – San Rafael (SFC)
Precipitation - Tipping Bucket
http://cdec.water.ca.gov/

Elevation: 120 ft
Lat: 37.998 º N
Long: 122.537 º W

Date	Time		Accumlated Rainfall (in)[a]	Incremental Rainfall (in)	Elapsed Time	Elapsed Time hr.	Elapsed Time min.	Intensity (in/hr)
02/16/2002	5:48:00	PM	7.74	0.01	0:02:00	0	2	0.30
02/16/2002	5:57:00	PM	7.75	0.01	0:09:00	0	9	0.07
02/16/2002	5:59:00	PM	7.76	0.01	0:02:00	0	2	0.30
02/16/2002	6:01:00	PM	7.77	0.01	0:02:00	0	2	0.30
02/16/2002	6:04:00	PM	7.78	0.01	0:03:00	0	3	0.20
02/16/2002	6:07:00	PM	7.79	0.01	0:03:00	0	3	0.20
02/16/2002	6:10:00	PM	7.80	0.01	0:03:00	0	3	0.20
02/16/2002	6:15:00	PM	7.81	0.01	0:05:00	0	5	0.12
02/16/2002	6:20:00	PM	7.84	0.03	0:05:00	0	5	0.36
02/16/2002	6:23:00	PM	7.85	0.01	0:03:00	0	3	0.20
02/16/2002	10:59:00	PM	7.86	0.01	4:36:00	4	36	0.00
02/16/2002	11:00:00	PM	7.87	0.01	0:01:00	0	1	0.60
02/16/2002	11:02:00	PM	7.88	0.01	0:02:00	0	2	0.30
02/17/2002	12:59:00	AM	7.89	0.01	1:57:00	1	57	0.01
02/17/2002	1:08:00	AM	7.90	0.01	0:09:00	0	9	0.07
02/17/2002	1:24:00	AM	7.91	0.01	0:16:00	0	16	0.04
02/17/2002	1:32:00	AM	7.92	0.01	0:08:00	0	8	0.07
02/17/2002	1:49:00	AM	7.93	0.01	0:17:00	0	17	0.04
02/17/2002	2:02:00	AM	7.94	0.01	0:13:00	0	13	0.05
02/17/2002	2:13:00	AM	7.95	0.01	0:11:00	0	11	0.05
02/17/2002	2:23:00	AM	7.97	0.02	0:10:00	0	10	0.12
02/17/2002	2:46:00	AM	7.98	0.01	0:23:00	0	23	0.03
02/17/2002	3:07:00	AM	7.99	0.01	0:21:00	0	21	0.03
02/17/2002	3:56:00	AM	8.00	0.01	0:49:00	0	49	0.01
02/17/2002	10:59:00	AM	8.00	0	7:03:00	7	3	0
02/18/2002	10:59:00	AM	8.00	0	24:00:00	24	0	0
02/18/2002	10:59:00	PM	8.00	0	12:00:00	12	0	0.00
02/19/2002	1:06:00	AM	8.01	0.01	2:07:00	2	7	0.00
02/19/2002	1:49:00	AM	8.05	0.04	0:43:00	0	43	0.06
02/19/2002	3:47:00	AM	8.06	0.01	1:58:00	1	58	0.01
02/19/2002	4:09:00	AM	8.07	0.01	0:22:00	0	22	0.03
02/19/2002	4:29:00	AM	8.08	0.01	0:20:00	0	20	0.03
02/19/2002	10:59:00	AM	8.13	0.05	6:30:00	6	30	0.01
02/19/2002	1:09:00	PM	8.14	0.01	2:10:00	2	10	0
02/19/2002	1:28:00	PM	8.16	0.02	0:19:00	0	19	0.06
02/19/2002	2:56:00	PM	8.20	0.04	1:28:00	1	28	0.03
02/19/2002	4:42:00	PM	8.21	0.01	1:46:00	1	46	0.01
02/19/2002	10:59:00	PM	8.21	0	6:17:00	6	17	0
02/20/2002	10:59:00	AM	8.21	0	12:00:00	12	0	0
02/20/2002	10:59:00	PM	8.21	0	12:00:00	12	0	0

Table A.2. (cont'd)

San Rafael Civic Center – San Rafael (SFC)
Precipitation - Tipping Bucket
http://cdec.water.ca.gov/

Elevation: 120 ft
Lat: 37.998 º N
Long: 122.537 º W

Date	Time		Accumlated Rainfall (in)[a]	Incremental Rainfall (in)	Elapsed Time	Elapsed Time hr.	Elapsed Time min.	Intensity (in/hr)
02/21/2002	10:59:00	AM	8.21	0	12:00:00	12	0	0
02/21/2002	10:59:00	PM	8.21	0	12:00:00	12	0	0
02/22/2002	10:59:00	AM	8.21	0	12:00:00	12	0	0
02/22/2002	10:59:00	PM	8.21	0	12:00:00	12	0	0
02/23/2002	10:59:00	AM	8.21	0	12:00:00	12	0	0
02/23/2002	1:42:00	PM	8.22	0.01	2:43:00	2	43	0
02/23/2002	10:59:00	PM	8.22	0	9:17:00	9	17	0
02/24/2002	10:59:00	AM	8.22	0	12:00:00	12	0	0
02/24/2002	10:59:00	PM	8.22	0	12:00:00	12	0	0
02/26/2002	10:59:00	AM	8.22	0	12:00:00	12	0	0
02/26/2002	10:59:00	PM	8.22	0	12:00:00	12	0	0
02/27/2002	10:59:00	AM	8.22	0	12:00:00	12	0	0
02/27/2002	10:59:00	PM	8.22	0	12:00:00	12	0	0
02/28/2002	10:59:00	AM	8.22	0	12:00:00	12	0	0
02/28/2002	10:59:00	PM	8.22	0	12:00:00	12	0	0
03/01/2002	10:59:00	AM	8.22	0	12:00:00	12	0	0
03/01/2002	10:59:00	PM	8.22	0	12:00:00	12	0	0
03/02/2002	10:59:00	AM	8.22	0	12:00:00	12	0	0
03/02/2002	10:59:00	PM	8.22	0	12:00:00	12	0	0
03/03/2002	10:59:00	AM	8.22	0	12:00:00	12	0	0
03/03/2002	10:59:00	PM	8.22	0	12:00:00	12	0	0
03/04/2002	10:59:00	AM	8.22	0	12:00:00	12	0	0
03/04/2002	10:59:00	PM	8.22	0	12:00:00	12	0	0
03/05/2002	10:59:00	PM	8.23	0.01	24:00:00	24	0	0
03/06/2002	12:02:00	AM	8.24	0.01	1:03:00	1	3	0.01
03/06/2002	12:25:00	AM	8.25	0.01	0:23:00	0	23	0.03
03/06/2002	12:55:00	AM	8.26	0.01	0:30:00	0	30	0.02
03/06/2002	1:15:00	AM	8.27	0.01	0:20:00	0	20	0.03
03/06/2002	1:31:00	AM	8.28	0.01	0:16:00	0	16	0.04
03/06/2002	1:46:00	AM	8.29	0.01	0:15:00	0	15	0.04
03/06/2002	2:08:00	AM	8.30	0.01	0:22:00	0	22	0.03
03/06/2002	2:28:00	AM	8.31	0.01	0:20:00	0	20	0.03
03/06/2002	2:55:00	AM	8.32	0.01	0:27:00	0	27	0.02
03/06/2002	3:20:00	AM	8.34	0.02	0:25:00	0	25	0.05
03/06/2002	4:37:00	AM	8.35	0.01	1:17:00	1	17	0.01
03/06/2002	4:51:00	AM	8.38	0.03	0:14:00	0	14	0.13
03/06/2002	4:58:00	AM	8.39	0.01	0:07:00	0	7	0.09
03/06/2002	5:14:00	AM	8.40	0.01	0:16:00	0	16	0.04
03/06/2002	5:31:00	AM	8.41	0.01	0:17:00	0	17	0.04
03/06/2002	5:42:00	AM	8.42	0.01	0:11:00	0	11	0.05

Table A.2. (cont'd)

San Rafael Civic Center – San Rafael (SFC)
Precipitation - Tipping Bucket
http://cdec.water.ca.gov/

Elevation: 120 ft
Lat: 37.998 º N
Long: 122.537 º W

Date	Time		Accumlated Rainfall (in)[a]	Incremental Rainfall (in)	Elapsed Time	Elapsed Time hr.	Elapsed Time min.	Intensity (in/hr)
03/06/2002	6:04:00	AM	8.43	0.01	0:22:00	0	22	0.03
03/06/2002	6:40:00	AM	8.44	0.01	0:36:00	0	36	0.02
03/06/2002	6:46:00	AM	8.45	0.01	0:06:00	0	6	0.10
03/06/2002	10:59:00	AM	8.45	0	4:13:00	4	13	0
03/06/2002	1:27:00	PM	8.46	0.01	2:28:00	2	28	0.00
03/06/2002	1:37:00	PM	8.47	0.01	0:10:00	0	10	0.06
03/06/2002	1:41:00	PM	8.48	0.01	0:04:00	0	4	0.15
03/06/2002	1:44:00	PM	8.49	0.01	0:03:00	0	3	0.20
03/06/2002	4:12:00	PM	8.51	0.02	2:28:00	2	28	0.01
03/06/2002	4:34:00	PM	8.52	0.01	0:22:00	0	22	0.03
03/06/2002	4:35:00	PM	8.53	0.01	0:01:00	0	1	0.60
03/06/2002	4:37:00	PM	8.55	0.02	0:02:00	0	2	0.60
03/06/2002	4:43:00	PM	8.56	0.01	0:06:00	0	6	0.10
03/06/2002	4:51:00	PM	8.57	0.01	0:08:00	0	8	0.07
03/06/2002	4:56:00	PM	8.58	0.01	0:05:00	0	5	0.12
03/06/2002	5:06:00	PM	8.59	0.01	0:10:00	0	10	0.06
03/06/2002	5:12:00	PM	8.60	0.01	0:06:00	0	6	0.10
03/06/2002	5:14:00	PM	8.61	0.01	0:02:00	0	2	0.30
03/06/2002	5:15:00	PM	8.62	0.01	0:01:00	0	1	0.60
03/06/2002	5:16:00	PM	8.63	0.01	0:01:00	0	1	0.60
03/06/2002	5:17:00	PM	8.64	0.01	0:01:00	0	1	0.60
03/06/2002	5:20:00	PM	8.65	0.01	0:03:00	0	3	0.20
03/06/2002	5:39:00	PM	8.66	0.01	0:19:00	0	19	0.03
03/06/2002	5:44:00	PM	8.67	0.01	0:05:00	0	5	0.12
03/06/2002	6:06:00	PM	8.68	0.01	0:22:00	0	22	0.03
03/06/2002	6:09:00	PM	8.69	0.01	0:03:00	0	3	0.20
03/06/2002	6:14:00	PM	8.70	0.01	0:05:00	0	5	0.12
03/06/2002	7:55:00	PM	8.71	0.01	1:41:00	1	41	0.01
03/06/2002	8:01:00	PM	8.72	0.01	0:06:00	0	6	0.10
03/06/2002	9:06:00	PM	8.73	0.01	1:05:00	1	5	0.01
03/06/2002	10:59:00	PM	8.73	0	1:53:00	1	53	0
03/07/2002	3:45:00	AM	8.74	0.01	4:46:00	4	46	0.00
03/07/2002	3:52:00	AM	8.75	0.01	0:07:00	0	7	0.09
03/07/2002	7:48:00	AM	8.76	0.01	3:56:00	3	56	0.00
03/07/2002	7:51:00	AM	8.77	0.01	0:03:00	0	3	0.20
03/07/2002	7:56:00	AM	8.78	0.01	0:05:00	0	5	0.12
03/07/2002	10:59:00	AM	8.79	0.01	3:03:00	3	3	0.00
03/07/2002	10:59:00	PM	8.79	0	12:00:00	12	0	0
03/08/2002	10:59:00	AM	8.79	0	12:00:00	12	0	0
03/09/2002	10:59:00	AM	8.79	0	24:00:00	24	12	0

Table A.2. (cont'd)

San Rafael Civic Center – San Rafael (SFC)
Precipitation - Tipping Bucket
http://cdec.water.ca.gov/

Elevation: 120 ft
Lat: 37.998 º N
Long: 122.537 º W

Date	Time		Accumlated Rainfall (in)[a]	Incremental Rainfall (in)	Elapsed Time	Elapsed Time hr.	Elapsed Time min.	Intensity (in/hr)
03/09/2002	10:47:00	PM	8.94	0.15	11:48:00	11	48	0.01
03/09/2002	10:57:00	PM	8.95	0.01	0:10:00	0	10	0.06
03/09/2002	10:59:00	PM	8.95	0	0:02:00	0	2	0
03/09/2002	11:03:00	PM	8.96	0.01	0:04:00	0	4	0.15
03/09/2002	11:36:00	PM	8.99	0.03	0:33:00	0	33	0.05
03/10/2002	1:55:00	AM	9.28	0.29	2:19:00	2	19	0.13
03/10/2002	2:13:00	AM	9.30	0.02	0:18:00	0	18	0.07
03/10/2002	2:21:00	AM	9.31	0.01	0:08:00	0	8	0.07
03/10/2002	2:39:00	AM	9.34	0.03	0:18:00	0	18	0.10
03/10/2002	3:21:00	AM	9.38	0.04	0:42:00	0	42	0.06
03/10/2002	3:31:00	AM	9.39	0.01	0:10:00	0	10	0.06
03/10/2002	3:41:00	AM	9.40	0.01	0:10:00	0	10	0.06
03/10/2002	3:45:00	AM	9.41	0.01	0:04:00	0	4	0.15
03/10/2002	3:53:00	AM	9.42	0.01	0:08:00	0	8	0.07
03/10/2002	4:06:00	AM	9.43	0.01	0:13:00	0	13	0.05
03/10/2002	5:21:00	AM	9.49	0.06	1:15:00	1	15	0.05
03/10/2002	10:59:00	AM	9.50	0.01	5:38:00	5	38	0.00
03/10/2002	10:59:00	PM	9.50	0	12:00:00	12	0	0
03/11/2002	10:59:00	AM	9.50	0	12:00:00	12	0	0
03/11/2002	10:59:00	PM	9.50	0	12:00:00	12	0	0
03/12/2002	10:59:00	AM	9.50	0	12:00:00	12	0	0
03/12/2002	10:59:00	PM	9.50	0	12:00:00	12	0	0
03/13/2002	10:59:00	AM	9.50	0	12:00:00	12	0	0
03/13/2002	10:59:00	PM	9.50	0	12:00:00	12	0	0
03/14/2002	10:59:00	AM	9.50	0	12:00:00	12	0	0
03/14/2002	10:59:00	PM	9.50	0	12:00:00	12	0	0

(a) Accumulated rain since 1/1/02 12:00AM.

Table A.3. Daily Precipitation, Including Rainfall Intensity, at San Leandro Bay Station, San Leandro, California, February 6 through March 15, 2002

San Leandro Bay (SLE) – San Leandro
Precipitation - Tipping Bucket
http://cdec.water.ca.gov/

Elevation: 10 ft
Lat: 37.7 º N
Long: 122.217 º W

Date	Time	Accumlated Rainfall (in)[a]	Incremental Rainfall (in)	Elapsed Time	Elapsed Time hr.	Elapsed Time min.	Intensity (in/hr)
02/06/2002	2:39:00 AM	27.52	-	-	-	-	-
02/07/2002	2:39:00 AM	27.52	0	24:00:00	0	0	0
02/07/2002	1:38:00 PM	27.56	0.04	10:59:00	10	59	0
02/07/2002	6:14:00 PM	27.60	0.04	4:36:00	4	36	0.01
02/07/2002	7:10:00 PM	27.64	0.04	0:56:00	0	56	0.04
02/07/2002	7:22:00 PM	27.68	0.04	0:12:00	0	12	0.20
02/07/2002	7:48:00 PM	27.72	0.04	0:26:00	0	26	0.09
02/08/2002	2:39:00 AM	27.72	0	6:51:00	6	51	0
02/08/2002	2:39:00 PM	27.72	0	12:00:00	0	0	0
02/09/2002	2:39:00 AM	27.72	0	12:00:00	0	0	0
02/09/2002	2:39:00 PM	27.72	0	12:00:00	0	0	0
02/10/2002	2:39:00 AM	27.72	0	12:00:00	0	0	0
02/10/2002	2:39:00 PM	27.72	0	12:00:00	0	0	0
02/12/2002	2:39:00 AM	27.72	0	12:00:00	0	0	0
02/12/2002	2:39:00 PM	27.72	0	12:00:00	0	0	0
02/13/2002	2:39:00 AM	27.72	0	12:00:00	0	0	0
02/13/2002	2:39:00 PM	27.72	0	12:00:00	0	0	0
02/13/2002	4:25:00 PM	27.76	0.04	1:46:00	1	46	0.02
02/13/2002	6:00:00 PM	27.80	0.04	1:35:00	1	35	0.03
02/14/2002	2:39:00 AM	27.80	0	8:39:00	8	39	0
02/14/2002	2:39:00 PM	27.80	0	12:00:00	0	0	0
02/15/2002	2:39:00 AM	27.80	0	12:00:00	0	0	0
02/15/2002	2:39:00 PM	27.80	0	12:00:00	0	0	0
02/16/2002	2:39:00 AM	27.80	0	12:00:00	0	0	0
02/16/2002	2:39:00 PM	27.80	0	12:00:00	0	0	0
02/16/2002	5:08:00 PM	27.83	0.03	2:29:00	2	29	0.01
02/16/2002	5:22:00 PM	27.87	0.04	0:14:00	0	14	0.17
02/16/2002	5:57:00 PM	27.91	0.04	0:35:00	0	35	0.07
02/16/2002	6:10:00 PM	27.95	0.04	0:13:00	0	13	0.18
02/16/2002	6:17:00 PM	27.99	0.04	0:07:00	0	7	0.34
02/16/2002	6:28:00 PM	28.03	0.04	0:11:00	0	11	0.22
02/17/2002	2:21:00 AM	28.11	0.08	7:53:00	7	53	0.01
02/17/2002	2:36:00 AM	28.15	0.04	0:15:00	0	15	0.16
02/17/2002	2:39:00 AM	28.15	0	0:03:00	0	3	0
02/17/2002	2:48:00 AM	28.19	0.04	0:09:00	0	9	0.27
02/17/2002	4:55:00 AM	28.31	0.12	2:07:00	2	7	0.06
02/17/2002	5:14:00 AM	28.35	0.04	0:19:00	0	19	0.13
02/17/2002	5:30:00 AM	28.39	0.04	0:16:00	0	16	0.15
02/17/2002	5:34:00 AM	28.47	0.08	0:04:00	0	4	**1.20**

Table A.3. (cont'd)

San Leandro Bay (SLE) – San Leandro
Precipitation - Tipping Bucket
http://cdec.water.ca.gov/

Elevation: 10 ft
Lat: 37.7 º N
Long: 122.217 º W

Date	Time	Accumlated Rainfall (in)[a]	Incremental Rainfall (in)	Elapsed Time	Elapsed Time hr.	Elapsed Time min.	Intensity (in/hr)
02/17/2002	6:19:00 AM	28.54	0.07	0:45:00	0	45	0.09
02/17/2002	6:43:00 AM	28.58	0.04	0:24:00	0	24	0.10
02/17/2002	2:39:00 PM	28.58	0	7:56:00	7	56	0
02/18/2002	12:41:00 AM	28.62	0.04	10:02:00	10	2	0
02/18/2002	2:39:00 AM	28.62	0	1:58:00	1	58	0
02/18/2002	2:39:00 PM	28.62	0	12:00:00	0	0	0
02/19/2002	2:39:00 AM	28.62	0	12:00:00	12	0	0
02/19/2002	4:57:00 AM	28.66	0.04	2:18:00	2	18	0.02
02/19/2002	5:37:00 AM	28.70	0.04	0:40:00	0	40	0.06
02/19/2002	11:06:00 AM	28.74	0.04	5:29:00	5	29	0.01
02/19/2002	1:35:00 PM	28.78	0.04	2:29:00	2	29	0.02
02/19/2002	2:13:00 PM	28.86	0.08	0:38:00	0	38	0.13
02/19/2002	2:39:00 PM	28.86	0	0:26:00	0	26	0
02/19/2002	3:21:00 PM	28.94	0.08	0:42:00	0	42	0.11
02/19/2002	4:24:00 PM	29.02	0.08	1:03:00	1	3	0.08
02/19/2002	4:49:00 PM	29.06	0.04	0:25:00	0	25	0.10
02/19/2002	5:46:00 PM	29.09	0.03	0:57:00	0	57	0.03
02/20/2002	2:39:00 AM	29.09	0	8:53:00	8	53	0
02/20/2002	2:39:00 PM	29.09	0	12:00:00	12	0	0
02/21/2002	2:39:00 AM	29.09	0	12:00:00	12	0	0
02/21/2002	2:39:00 PM	29.09	0	12:00:00	12	0	0
02/22/2002	2:39:00 AM	29.09	0	12:00:00	12	0	0
02/22/2002	10:46:00 PM	29.17	0.08	8:07:00	8	7	0.01
02/23/2002	2:39:00 AM	29.17	0	3:53:00	3	53	0
02/23/2002	6:23:00 AM	29.25	0.08	3:44:00	3	44	0.02
02/23/2002	7:07:00 AM	29.33	0.08	0:44:00	0	44	0.11
02/23/2002	8:41:00 AM	29.41	0.08	1:34:00	1	34	0.05
02/23/2002	2:39:00 PM	29.41	0	5:58:00	5	58	0
02/23/2002	11:22:00 PM	29.49	0.08	8:43:00	8	43	0.01
02/24/2002	12:06:00 AM	29.65	0.16	0:44:00	0	44	0.22
02/24/2002	1:37:00 AM	29.72	0.07	1:31:00	1	31	0.05
02/24/2002	2:39:00 AM	29.72	0	1:02:00	1	2	0
02/24/2002	3:50:00 AM	29.80	0.08	1:11:00	1	11	0.07
02/25/2002	2:39:00 AM	29.80	0	22:49:00	22	49	0
02/25/2002	2:39:00 PM	29.80	0	12:00:00	12	0	0
02/26/2002	2:39:00 PM	29.80	0	24:00:00	24	12	0
02/27/2002	2:39:00 AM	29.80	0	12:00:00	12	0	0
02/27/2002	2:39:00 PM	29.80	0	12:00:00	12	0	0
02/28/2002	2:39:00 AM	29.80	0	12:00:00	12	0	0
02/28/2002	2:39:00 PM	29.80	0	12:00:00	12	0	0

Table A.3. (cont'd)

San Leandro Bay (SLE) – San Leandro
Precipitation - Tipping Bucket
http://cdec.water.ca.gov/

Elevation: 10 ft
Lat: 37.7 º N
Long: 122.217 º W

Date	Time	Accumlated Rainfall (in)[a]	Incremental Rainfall (in)	Elapsed Time	Elapsed Time hr.	Elapsed Time min.	Intensity (in/hr)
03/01/2002	2:39:00 PM	29.80	0	24:00:00	24	12	0
03/02/2002	2:39:00 AM	29.80	0	12:00:00	12	0	0
03/02/2002	2:39:00 PM	29.80	0	12:00:00	12	0	0
03/03/2002	2:39:00 AM	29.80	0	12:00:00	12	0	0
03/03/2002	2:39:00 PM	29.80	0	12:00:00	12	0	0
03/04/2002	2:39:00 AM	29.80	0	12:00:00	12	0	0
03/04/2002	2:39:00 PM	29.80	0	12:00:00	12	0	0
03/05/2002	2:39:00 AM	29.80	0	12:00:00	12	0	0
03/05/2002	2:39:00 PM	29.80	0	12:00:00	12	0	0
03/06/2002	2:39:00 AM	29.80	0	12:00:00	12	0	0
03/06/2002	3:46:00 AM	29.84	0.04	1:07:00	1	7	0.04
03/06/2002	6:52:00 AM	29.88	0.04	3:06:00	3	6	0.01
03/06/2002	8:08:00 AM	29.92	0.04	1:16:00	1	16	0.03
03/06/2002	2:39:00 PM	30.00	0.08	6:31:00	6	31	0.01
03/06/2002	6:06:00 PM	30.04	0.04	3:27:00	3	27	0.01
03/06/2002	7:05:00 PM	30.12	0.08	0:59:00	0	59	0.08
03/06/2002	7:23:00 PM	30.16	0.04	0:18:00	0	18	0.13
03/06/2002	7:43:00 PM	30.20	0.04	0:20:00	0	20	0.12
03/06/2002	8:06:00 PM	30.24	0.04	0:23:00	0	23	0.10
03/07/2002	2:39:00 AM	30.24	0	6:31:00	6	31	0
03/07/2002	7:03:00 AM	30.28	0.04	4:24:00	4	24	0.01
03/07/2002	7:47:00 AM	30.32	0.04	0:44:00	0	44	0.05
03/07/2002	8:07:00 AM	30.35	0.03	0:20:00	0	20	0.09
03/07/2002	9:31:00 AM	30.39	0.04	1:24:00	1	24	0.03
03/07/2002	9:56:00 AM	30.43	0.04	0:25:00	0	25	0.10
03/07/2002	2:39:00 PM	30.51	0.08	4:43:00	4	43	0.02
03/08/2002	2:39:00 AM	30.51	0	12:00:00	12	0	0
03/08/2002	7:26:00 AM	30.59	0.08	4:47:00	4	47	0.02
03/08/2002	2:39:00 PM	30.59	0	7:13:00	7	13	0
03/08/2002	6:47:00 PM	30.67	0.08	4:08:00	4	8	0.02
03/09/2002	8:43:00 AM	30.98	0.31	13:56:00	1	56	0.16
03/09/2002	2:40:00 PM	30.98	0	5:57:00	5	57	0
03/09/2002	11:04:00 PM	31.02	0.04	8:24:00	8	24	0.00
03/09/2002	11:16:00 PM	31.06	0.04	0:12:00	0	12	0.20
03/10/2002	1:18:00 AM	31.14	0.08	2:02:00	2	2	0.04
03/10/2002	2:40:00 AM	31.18	0.04	1:22:00	1	22	0.03
03/10/2002	3:07:00 AM	31.22	0.04	0:27:00	0	27	0.09
03/10/2002	5:12:00 AM	31.26	0.04	2:05:00	2	5	0.02
03/10/2002	6:10:00 AM	31.30	0.04	0:58:00	0	58	0.04
03/10/2002	2:40:00 PM	31.30	0	8:30:00	8	30	0

Table A.3. (cont'd)

San Leandro Bay (SLE) – San Leandro
Precipitation - Tipping Bucket
http://cdec.water.ca.gov/

Elevation: 10 ft
Lat: 37.7 º N
Long: 122.217 º W

Date	Time	Accumlated Rainfall (in)[a]	Incremental Rainfall (in)	Elapsed Time	Elapsed Time hr.	Elapsed Time min.	Intensity (in/hr)
03/11/2002	2:40:00 AM	31.30	0	12:00:00	12	0	0
03/11/2002	2:40:00 PM	31.30	0	12:00:00	12	0	0
03/12/2002	2:40:00 PM	31.30	0	12:00:00	12	0	0
03/13/2002	2:40:00 AM	31.30	0	12:00:00	12	0	0
03/13/2002	2:40:00 PM	31.30	0	12:00:00	12	0	0
03/14/2002	2:40:00 AM	31.30	0	12:00:00	12	0	0
03/14/2002	2:40:00 PM	31.30	0	12:00:00	12	0	0

(a) Accumulated rain since 1/1/02 12:00AM.

Table A.4. Daily Precipitation, Including Rainfall Intensity, at Arroyo Corte Madera Station, Mill Valley, California, February 6 through March 15, 2002

Arroyo Corte Madera - Mill Valley (ACM)
Precipitation - Tipping Bucket
http://cdec.water.ca.gov/

Elevation: 3 ft
Lat: 37.898 º N
Long: 122.535 º W

Date	Time	Accumlated Rainfall (in)[a]	Incremental Rainfall (in)	Elapsed Time	Elapsed Time		Intensity (in/hr)
					hr.	min.	
02/06/2002	8:44:00 AM	25.28	-	-	-	-	-
02/07/2002	12:05:00 AM	25.32	0.04	3:21:00	3	21	0.01
02/07/2002	5:08:00 AM	25.35	0.03	10:59:00	10	59	0
02/07/2002	9:07:00 AM	25.35	0	3:59:00	3	59	0
02/07/2002	1:58:00 PM	25.39	0.04	4:51:00	4	51	0.01
02/07/2002	3:08:00 PM	25.43	0.04	1:10:00	1	10	0.03
02/07/2002	5:50:00 PM	25.59	0.16	2:42:00	2	42	0.06
02/07/2002	5:59:00 PM	25.63	0.04	0:09:00	0	9	0.27
02/07/2002	6:10:00 PM	25.67	0.04	0:11:00	0	11	0.22
02/07/2002	6:20:00 PM	25.71	0.04	0:10:00	0	10	0.24
02/07/2002	6:35:00 PM	25.75	0.04	0:15:00	0	15	0.16
02/07/2002	6:47:00 PM	25.79	0.04	0:12:00	0	12	0.20
02/07/2002	9:19:00 PM	25.83	0.04	2:32:00	2	32	0.02
02/08/2002	8:05:00 AM	25.87	0.04	10:46:00	10	46	0
02/08/2002	9:31:00 AM	25.87	0	1:26:00	1	26	0
02/09/2002	9:55:00 AM	25.87	0	0:24:00	0	24	0
02/09/2002	10:07:00 PM	25.87	0	0:12:00	0	12	0
02/10/2002	10:18:00 AM	25.87	0	0:11:00	0	11	0
02/11/2002	10:42:00 AM	25.87	0	0:24:00	0	24	0
02/11/2002	10:54:00 PM	25.87	0	0:12:00	0	12	0
02/12/2002	11:06:00 AM	25.87	0	0:12:00	0	12	0
02/12/2002	11:18:00 PM	25.87	0	0:12:00	0	12	0
02/13/2002	11:30:00 AM	25.87	0	0:12:00	0	12	0
02/13/2002	1:36:00 PM	25.91	0.04	2:06:00	2	6	0.02
02/13/2002	2:35:00 PM	25.94	0.03	0:59:00	0	59	0.03
02/13/2002	3:12:00 PM	25.98	0.04	0:37:00	0	37	0.06
02/13/2002	11:41:00 PM	25.98	0	8:29:00	8	29	0
02/13/2002	11:58:00 PM	26.02	0.04	0:17:00	12	17	0
02/14/2002	11:53:00 AM	26.02	0	11:55:00	11	55	0
02/15/2002	12:05:00 AM	26.02	0	0:12:00	0	12	0
02/16/2002	12:41:00 PM	26.02	0	0:36:00	0	36	0
02/16/2002	4:43:00 PM	26.06	0.04	4:02:00	4	2	0.01
02/16/2002	4:51:00 PM	26.10	0.04	0:08:00	0	8	0.30
02/16/2002	4:58:00 PM	26.14	0.04	0:07:00	0	7	0.34
02/16/2002	5:05:00 PM	26.18	0.04	0:07:00	0	7	0.34
02/16/2002	5:14:00 PM	26.22	0.04	0:09:00	0	9	0.27
02/16/2002	5:24:00 PM	26.26	0.04	0:10:00	0	10	0.24
02/16/2002	5:48:00 PM	26.34	0.08	0:24:00	0	24	0.20

Table A.4. (cont'd)

Arroyo Corte Madera - Mill Valley (ACM)
Precipitation - Tipping Bucket
http://cdec.water.ca.gov/

Elevation: 3 ft
Lat: 37.898 º N
Long: 122.535 º W

Date	Time	Accumlated Rainfall (in)[a]	Incremental Rainfall (in)	Elapsed Time	Elapsed Time		Intensity (in/hr)
					hr.	min.	
02/16/2002	5:56:00 PM	26.38	0.04	0:08:00	0	8	0.30
02/16/2002	6:11:00 PM	26.42	0.04	0:15:00	0	15	0.16
02/16/2002	6:20:00 PM	26.46	0.04	0:09:00	0	9	0.27
02/17/2002	12:53:00 AM	26.46	0	6:33:00	6	33	0
02/17/2002	2:24:00 AM	26.53	0.07	1:31:00	1	31	0.05
02/17/2002	3:07:00 AM	26.58	0.05	0:43:00	0	43	0.07
02/17/2002	3:56:00 AM	26.61	0.03	0:49:00	0	49	0.04
02/17/2002	4:47:00 AM	26.65	0.04	0:51:00	0	51	0.05
02/17/2002	1:04:00 PM	26.65	0	8:17:00	8	17	0
02/19/2002	1:02:00 AM	26.69	0.04	23:58:00	23	58	0.002
02/19/2002	2:38:00 AM	26.77	0.08	1:36:00	1	36	0.05
02/19/2002	3:22:00 AM	26.81	0.04	0:44:00	0	44	0.05
02/19/2002	5:06:00 AM	26.97	0.16	1:44:00	1	44	0.09
02/19/2002	5:27:00 AM	27.01	0.04	0:21:00	0	21	0.11
02/19/2002	5:47:00 AM	27.05	0.04	0:20:00	0	20	0.12
02/19/2002	6:10:00 AM	27.09	0.04	0:23:00	0	23	0.10
02/19/2002	6:28:00 AM	27.13	0.04	0:18:00	0	18	0.13
02/19/2002	6:58:00 AM	27.17	0.04	0:30:00	0	30	0.08
02/19/2002	7:49:00 AM	27.20	0.03	0:51:00	0	51	0.04
02/19/2002	8:05:00 AM	27.24	0.04	0:16:00	0	16	0.15
02/19/2002	8:43:00 AM	27.32	0.08	0:38:00	0	38	0.13
02/19/2002	9:02:00 AM	27.36	0.04	0:19:00	0	19	0.13
02/19/2002	9:23:00 AM	27.40	0.04	0:21:00	0	21	0.11
02/19/2002	9:47:00 AM	27.44	0.04	0:24:00	0	24	0.10
02/19/2002	10:10:00 AM	27.48	0.04	0:23:00	0	23	0.10
02/19/2002	10:42:00 AM	27.52	0.04	0:32:00	0	32	0.07
02/19/2002	11:10:00 AM	27.56	0.04	0:28:00	0	28	0.09
02/19/2002	11:31:00 AM	27.60	0.04	0:21:00	0	21	0.11
02/19/2002	11:47:00 AM	27.64	0.04	0:16:00	0	16	0.15
02/19/2002	12:26:00 PM	27.72	0.08	0:39:00	0	39	0.12
02/19/2002	12:44:00 PM	27.76	0.04	0:18:00	0	18	0.13
02/19/2002	1:29:00 PM	27.87	0.11	0:45:00	0	45	0.15
02/19/2002	2:04:00 PM	27.95	0.08	0:35:00	0	35	0.14
02/19/2002	5:04:00 PM	28.03	0.08	3:00:00	3	0	0.03
02/19/2002	9:54:00 PM	28.07	0.04	4:50:00	4	50	0.01
02/19/2002	11:16:00 PM	28.11	0.04	1:22:00	1	22	0.03
02/20/2002	12:01:00 AM	28.15	0.04	0:45:00	0	45	0.05
02/20/2002	1:00:00 AM	28.19	0.04	0:59:00	0	59	0.04
02/20/2002	2:04:00 AM	28.19	0	1:04:00	1	4	0

Table A.4. (cont'd)

Arroyo Corte Madera - Mill Valley (ACM)
Precipitation - Tipping Bucket
http://cdec.water.ca.gov/

Elevation: 3 ft
Lat: 37.898 º N
Long: 122.535 º W

Date	Time	Accumlated Rainfall (in)[a]	Incremental Rainfall (in)	Elapsed Time	Elapsed Time hr.	Elapsed Time min.	Intensity (in/hr)
02/20/2002	2:34:00 AM	28.23	0.04	0:30:00	0	30	0.08
02/20/2002	3:15:00 AM	28.27	0.04	0:41:00	0	41	0.06
02/20/2002	4:39:00 AM	28.31	0.04	1:24:00	1	24	0.03
02/20/2002	6:18:00 AM	28.35	0.04	1:39:00	1	39	0.02
02/20/2002	2:15:00 PM	28.35	0	7:57:00	7	57	0
02/21/2002	2:27:00 AM	28.35	0	0:12:00	0	12	0
02/21/2002	2:39:00 PM	28.35	0	0:12:00	0	12	0
02/22/2002	2:51:00 AM	28.35	0	0:12:00	0	12	0
02/22/2002	3:03:00 PM	28.35	0	0:12:00	0	12	0
02/22/2002	11:07:00 PM	28.39	0.04	8:04:00	8	4	0.005
02/23/2002	3:15:00 AM	28.39	0	4:08:00	4	8	0
02/23/2002	3:27:00 PM	28.39	0	0:12:00	0	12	0
02/24/2002	3:50:00 PM	28.39	0	0:23:00	0	23	0
02/25/2002	4:14:00 PM	28.39	0	0:24:00	0	24	0
02/27/2002	5:01:00 PM	28.39	0	0:47:00	0	47	0
02/28/2002	5:13:00 AM	28.39	0	0:12:00	0	12	0
02/28/2002	5:25:00 PM	28.39	0	0:12:00	0	12	0
03/01/2002	5:37:00 AM	28.39	0	0:12:00	0	12	0
03/01/2002	5:49:00 PM	28.39	0	0:12:00	0	12	0
03/02/2002	6:13:00 PM	28.39	0	0:24:00	0	24	0
03/03/2002	6:36:00 PM	28.39	0	0:23:00	0	23	0
03/04/2002	7:00:00 PM	28.39	0	0:24:00	0	24	0
03/05/2002	7:12:00 AM	28.39	0	0:12:00	0	12	0
03/05/2002	7:24:00 PM	28.39	0	0:12:00	0	12	0
03/05/2002	9:50:00 PM	28.42	0.03	2:26:00	2	26	0.01
03/05/2002	11:02:00 PM	28.47	0.05	1:12:00	1	12	0.04
03/05/2002	11:42:00 PM	28.50	0.03	0:40:00	0	40	0.05
03/06/2002	12:00:00 AM	28.54	0.04	0:18:00	0	18	0.13
03/06/2002	12:26:00 AM	28.62	0.08	0:26:00	0	26	0.18
03/06/2002	12:36:00 AM	28.66	0.04	0:10:00	0	10	0.24
03/06/2002	12:54:00 AM	28.70	0.04	0:18:00	0	18	0.13
03/06/2002	1:16:00 AM	28.74	0.04	0:22:00	0	22	0.11
03/06/2002	1:40:00 AM	28.78	0.04	0:24:00	0	24	0.10
03/06/2002	1:53:00 AM	28.82	0.04	0:13:00	0	13	0.18
03/06/2002	2:16:00 AM	28.86	0.04	0:23:00	0	23	0.10
03/06/2002	2:35:00 AM	28.90	0.04	0:19:00	0	19	0.13
03/06/2002	3:03:00 AM	28.94	0.04	0:28:00	0	28	0.09
03/06/2002	3:56:00 AM	28.98	0.04	0:53:00	0	53	0.05
03/06/2002	6:40:00 AM	29.02	0.04	2:44:00	2	44	0.01

Table A.4. (cont'd)

Arroyo Corte Madera - Mill Valley (ACM)
Precipitation - Tipping Bucket
http://cdec.water.ca.gov/

Elevation: 3 ft
Lat: 37.898 º N
Long: 122.535 º W

Date	Time	Accumlated Rainfall (in)[a]	Incremental Rainfall (in)	Elapsed Time	Elapsed Time hr.	Elapsed Time min.	Intensity (in/hr)
03/06/2002	7:36:00 AM	29.02	0	0:56:00	0	56	0
03/06/2002	11:26:00 AM	29.06	0.04	3:50:00	3	50	0.01
03/06/2002	4:48:00 PM	29.09	0.03	5:22:00	5	22	0.01
03/06/2002	5:03:00 PM	29.13	0.04	0:15:00	0	15	0.16
03/06/2002	5:16:00 PM	29.17	0.04	0:13:00	0	13	0.18
03/06/2002	5:26:00 PM	29.21	0.04	0:10:00	0	10	0.24
03/06/2002	5:54:00 PM	29.25	0.04	0:28:00	0	28	0.09
03/06/2002	6:07:00 PM	29.29	0.04	0:13:00	0	13	0.18
03/06/2002	7:47:00 PM	29.29	0	1:40:00	1	40	0
03/06/2002	8:12:00 PM	29.33	0.04	0:25:00	0	25	0.10
03/06/2002	8:49:00 PM	29.37	0.04	0:37:00	0	37	0.06
03/07/2002	5:14:00 AM	29.41	0.04	8:25:00	8	25	0.00
03/07/2002	7:59:00 AM	29.41	0	2:45:00	2	45	0
03/07/2002	8:37:00 AM	29.45	0.04	0:38:00	0	38	0.06
03/07/2002	8:42:00 AM	29.49	0.04	0:05:00	0	5	0.48
03/07/2002	8:11:00 PM	29.49	0	11:29:00	11	29	0
03/09/2002	8:47:00 AM	29.49	0	0:36:00	0	36	0
03/09/2002	10:47:00 PM	30.00	0.51	2:00:00	2	0	0.26
03/09/2002	11:14:00 PM	30.04	0.04	0:27:00	0	27	0.09
03/10/2002	12:15:00 AM	30.12	0.08	1:01:00	1	1	0.08
03/10/2002	4:11:00 AM	30.35	0.23	3:56:00	3	56	0.06
03/10/2002	4:48:00 AM	30.43	0.08	0:37:00	0	37	0.13
03/10/2002	9:10:00 AM	30.47	0.04	4:22:00	4	22	0.01
03/10/2002	9:22:00 PM	30.47	0	12:12:00	12	12	0
03/11/2002	9:34:00 AM	30.47	0	12:12:00	12	12	0
03/11/2002	9:46:00 PM	30.47	0	12:12:00	12	12	0
03/12/2002	9:58:00 AM	30.47	0	12:12:00	12	12	0
03/13/2002	10:22:00 AM	30.47	0	0:24:00	0	24	0
03/13/2002	10:33:00 PM	30.47	0	12:11:00	12	11	0
03/14/2002	10:45:00 AM	30.47	0	12:12:00	12	12	0
03/14/2002	10:57:00 PM	30.47	0	12:12:00	12	12	0

(a) Accumulated rain since 1/1/02 12:00AM.

APPENDIX B

EPA FIELD SUMMARY REPORTS

FEBRUARY/MARCH 2002 and JULY 2002

Field Sampling Summary for
Mussels, Surface Water, Sediments and Passive Samplers
at the United Heckathorn Site in
Richmond, California, conducted 2/6 - 3/5/2002.

Andrew Lincoff
EPA Region 9 Laboratory
PMD-2
April 10, 2002

INTRODUCTION

This sampling event involved the deployment of passive samplers and sediment traps in outfalls at the United Heckathorn Superfund Site and at other locations in Richmond Harbor in Richmond, California. The samplers were subsequently collected along with mussels and surface water samples. Deployment was performed on February 6, 2002 by Andrew Lincoff and Peter Husby of the EPA Region 9 Laboratory, and Carmen White, United Heckathorn RPM. Samples were collected on March 5, 2002 by Peter Husby, Carmen White and Patrick Borthwick, of the EPA Region 9 Laboratory. Sampling was performed in accordance with Battelle's "United Heckathorn Post-Remediation Field Monitoring Plan" (FSP), dated February 5, 1997, and "Sampling and Analysis Plan for the Investigation of Contaminant Source and Contaminant Movement in the Lauritzen Channel, United Heckathorn Site, Richmond, California" (SAP), drafted January 11, 2002.

OBJECTIVE

EPA conducted this field sampling as part of the oversight of a final Remedial Action under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) at the United Heckathorn Site in Richmond, California. The sampling effort involved collecting physical environmental samples to analyze for the presence of hazardous substances.

The United Heckathorn Site was used to formulate pesticides from approximately 1947 to 1966. Soils at the Site and sediments in Richmond Harbor were contaminated with various chlorinated pesticides, primarily DDT, as a result of these pesticide formulation activities. The final remedy contained in EPA's October, 1994 Record of Decision addressed remaining hazardous substances, primarily in the marine environment. The major marine components of the selected remedy included:

- Dredging of all soft bay mud from the Lauritzen Channel and Parr Canal, with offsite disposal of dredged material.

- Marine monitoring to verify the effectiveness of the remedy.

The first component of the remedy selected in the ROD called for dredging all "young bay mud" from those channels in Richmond Harbor which contained average DDT concentrations greater than 590 ppb (dry wt.). The dredging was completed in April, 1997. The short-term monitoring, performed according to EPA's September 5, 1996 FSP, consisted of sediment chemistry monitoring to ensure that the average sediment concentration after dredging was below the cleanup level selected in the ROD. This monitoring was completed shortly prior to the placement of the sand cap in April, 1997. Subsequent monitoring has found some remaining contamination of surface sediment.

Long-term monitoring is addressed by Battelle's February 5, 1997 FSP. The purpose of the long-term monitoring is to demonstrate the effectiveness of the remedy. Prior to the remediation, mussels in the Lauritzen Channel contained the highest levels of DDT and dieldrin in the State, and surface water exceeded EPA's Ambient Water Quality Criteria for DDT by a factor of 50. Lower but still elevated levels were found in mussels and surface water in the Santa Fe Channel. It was concluded in EPA's Remedial Investigation that these elevated levels were the result of continuous flux from contaminated sediments. Approximately 98% of the mass of DDT in sediments in Richmond Harbor was removed by the remedial dredging. The long-term monitoring will demonstrate whether this action has succeeded in reducing the levels of DDT in mussels and surface waters.

Battelle's FSP included monitoring using both transplanted California mussels and resident Bay mussels. The first round of the long-term sampling occurred in January, 1998. This is the fifth annual round of sampling. The seasonal timing was chosen to match the protocol used by the California State Mussel Watch Program, in order to permit comparison with the State's results over the past 15 years. In the first two rounds, both transplanted and resident mussels are analyzed to determine any difference. Based on the results of the first two rounds and discussions with California State Mussel Watch Program personnel, only resident mussels were collected in subsequent rounds. Mussels and water samples collected on March 6, 2002 were shipped to Battelle for analysis.

Battelle's SAP contains additional monitoring of sediments, sediment traps in outfalls, and passive samplers in an attempt to determine contaminant sources. The sediment traps and passive samplers were deployed on February 6 and collected on March 6, 2002. The passive samplers were shipped to Battelle for analysis. Sediment samples collected on February 6 were returned to the EPA Region 9 Laboratory for analysis. Additional sediment samples and the sediment traps were collected by the Battelle field team during the week of March 11, 2002.

FIELD NOTES AND OBSERVATIONS

1. Sediment traps manufactured by Battelle were deployed at two outfalls in the Lauritzen Channel on February 6, 2002. The GPS locations of the sediment traps are listed in Table 1. The first sediment trap (ST-1) was deployed in the large storm drain outfall at the head of the channel as shown in Photo 1. Clear water was flowing from the storm drain. The flow was approximately 1 inch deep. The end of the storm drain was not square so most of the flow poured out below the trap although there was a small continuous flow through the trap. The second sediment trap (ST-2) was placed in an 8-inch pipe on the eastern shore of the Lauritzen Channel as shown in Photo 2. Again the pipe was not square so the small flow of about 100 drops per minute did not go through the trap. An attempt was made to place another sediment trap on a 5 ½ inch pipe near ST-2, but none of the trap mounts were small enough. The 5 ½ inch pipe had no flow and contained no sediment.

2. Eight passive polyethylene samplers were placed in the Lauritzen, Santa Fe and Richmond Inner Harbor Channels on February 6, 2002. Two were placed in the two outfalls with sediment traps (ST-1 and ST-2). PS-1 was placed 128 inches up the storm drain and PS-2 was placed approximately one foot up the pipe. PS-3 was hung from the remnants of a small pier on the eastern shore of the northern Lauritzen, shown in Photo 3. PS-4 was hung from a ladder beneath the Manson pier on the western shore of the Lauritzen, shown in Photo 4. The locations of PS-5, PS-6, PS-7 and PS-8 are approximately the same as the routine mussel sampling stations 303.3 (northern Lauritzen), 303.2 (Lauritzen mouth), 303.4 (Santa Fe), and 303.1 (Richmond Inner Harbor Channel mouth). No photos are available for PS-5 and PS-6. PS-7 is shown in Photo 5 and PS-8 in Photo 6. The GPS locations of the passive samplers are also listed in Table 1.

3. Additional pipes which were not sampled are shown in Photos 8 and 9. The GPS location for the 'L'-shaped pipe in Photo 7 is 37º 55' 25.207" N, 122º 21' 59.031" W. The 'L'-shaped pipe had a gate valve which appeared to be closed. The pipe in Photo 8 was under the Levin pier at station 20. No accurate GPS reading could be taken for this pipe because of its location under the pier. An approximate GPS location is the same as listed in Table 1 for sediment sample S-5, discussed below. Two outfalls that were identified on a City of Richmond drainage map as discharging to Lauritzen Channel (15 and 21 inch diameter) were planned for passive sampler and sediment sampling, but the two pipes were not found at low tide.

4. Sediment samples were collected from the storm drain (S-1) and 8 inch pipe (S-2) shown in Photos 1 and 2. Two sediment samples were collected from the Lauritzen Channel embankment near the small floating dock next to the Levin pier. These samples were taken from a distinct light sediment layer (S-3) overlying a darker layer (S-4) shown in Photo 9. An additional sediment sample (S-5) was collected from a light-colored soil layer near the base of the pipe under the Levin pier at station 20, shown in Photo 8. The soil was about 5 feet above the water level. The GPS location

for this sample is approximate because it was under the pier. The location coordinates given for this sample are from the closest point outside the pier where GPS satellites could be received. The sediment samples were promptly submitted on 2/6/02 to the Region 9 Lab for analysis of pesticides and PCBs.

5. The passive samplers, seawater samples, and resident bay mussels were collected on March 5, 2002, with the exception of PS-2 which was retrieved on March 14 by Battelle. The seawater and mussel samples were given the routine Mussel Watch station numbers 303.1 to 303.4 used in the previous annual collections. An additional station was established in the Parr Canal and given station number 303.6. Three gallons of seawater were collected from approximately one foot below the surface at each location. An additional two gallons were collected at station 303.2 for lab QC. Forty-five mussels were collected at each station. The mussels were all collected near the surface, which at the collection time was approximately at 1 ft above Mean Lower Low Water (MLLW) except for station 303.4 where the mussels were collected near the surface from a floating dock. The samples were promptly delivered to the Region 9 Lab and the seawaters and passive samplers were placed in a 4 C cold room. The mussels were cleaned of gross debris in the laboratory's clean filtered seawater, wrapped in ashed foil, placed in zip-loc bags, and stored in a –20º C freezer. The passive samplers, seawaters and mussels were packaged and shipped on March 7, 2002 by Fed Ex to Battelle for analysis of pesticides and PCBs.

Table 1. Sample Locations

Sample ID	GPS Coordinates (NAD 83)[a]		Remarks
	Lat	Long	
ST-1, PS-1, S-1	37º 55' 28.589" N	122º 21' 59.477" W	sed. trap, passive sampler, sediment
ST-2, PS-2, S-2	37º 55' 25.556" N	122º 21' 59.441" W	sed. trap, passive sampler, sediment
PS-3	37º 55' 25.760" N	122º 21' 59.551" W	passive sampler
PS-4	37º 55' 21.523" N	122º 22' 02.221" W	passive sampler
PS-5, 303.3	37º 55' 28.589" N	122º 21' 59.477" W	passive sampler, seawater, mussels
PS-6, 303.2	37º 55' 22.699" N	122º 22' 00.094" W	passive sampler, seawater, mussels
PS-7, 303.4	37º 55' 21.235" N	122º 22' 17.684" W	passive sampler, seawater, mussels
PS-8, 303.1	37º 54' 32.869" N	122º 21' 33.523" W	passive sampler, seawater, mussels
303.6	37º 55' 11.817" N	122º 21' 45.996" W	seawater, mussels
S-3, S-4	37º 55' 28.589" N	122º 21' 59.477" W	sediment
S-5	37º 55' 18.717" N	122º 22' 00.899" W	sediment

(a) Location coordinates were determined using GPS with differential correction.

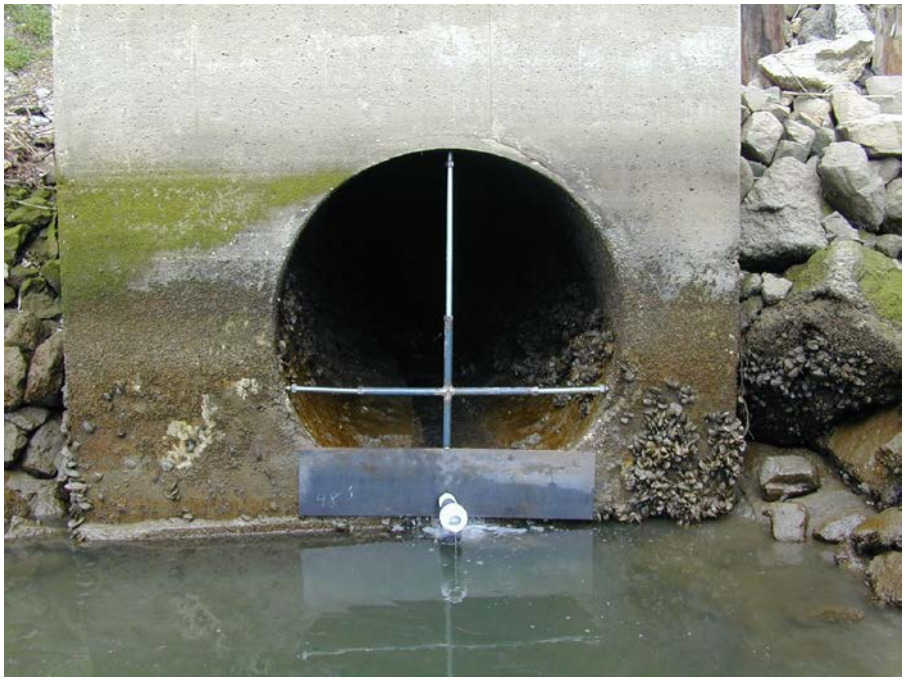


Photo 1 - Sediment Trap 1 (ST-1) and Passive Sampler 1 (PS-1) installation. 2/6/02.

Photo 2 - Sediment Trap 2 (ST-2) and Passive Sampler 2 (PS-2) installation. 2/6/02.

Photo 3 - Passive Sampler 3 (PS-3) installation,
northern Lauritzen Channel. 2/6/02.

Photo 4 - Passive Sampler 4 (PS-4) installation,
beneath Manson dock. 2/6/02.

Photo 5 - Passive Sampler 7 (PS-7) installation,
Santa Fe Channel. 2/6/02.

Photo 6 - Passive Sampler 8 (PS-8) installation,
Richmond Inner Harbor Channel. 2/6/02.

Photo 7 - ‘L’-shaped pipe with gate valve. 2/6/02.

Photo 8 - Pipe under Levin dock near sediment sample S-5. 2/6/02.

Photo 9 - Lauritzen bank sediment sampling locations S-3 and S-4. 2/6/02.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION IX LABORATORY

1337 S. 46TH STREET

BLDG 201

RICHMOND, CA 94804-4698

September 5, 2002

MEMORANDUM

SUBJECT: Summary of United Heckathorn Post-Remedial Sediment Sampling 7/16 - 7/17/2002.

FROM: Andrew Lincoff, PMD-2
Regional Laboratory

TO: Carmen White, SFD-7-3
Remedial Project Manager

INTRODUCTION

This sampling event involved the collecction of sediment samples at the United Heckathorn Superfund Site in Richmond, California. Sampling was performed on February 6, 2002 by Andrew Lincoff and Peter Husby of the EPA Region 9 Laboratory, and Carmen White, United Heckathorn RPM. Sampling was performed in accordance with Battelle=s AUnited Heckathorn Post-Remediation Field Monitoring Plan@ (FSP), dated February 5, 1997, and ASampling and Analysis Plan for the Investigation of Contaminant Source and Contaminant Movement in the Lauritzen Channel, United Heckathorn Site, Richmond, California@ (SAP), drafted January 11, 2002.

OBJECTIVE

EPA conducted this field sampling as part of the oversight of a final Remedial Action under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) at the United Heckathorn Site in Richmond, California. The sampling effort involved collecting physical environmental samples to analyze for the presence of hazardous substances.

The United Heckathorn Site was used to formulate pesticides from approximately 1947 to 1966. Soils at the Site and sediments in Richmond Harbor were contaminated with various chlorinated pesticides, primarily DDT, as a result of these pesticide formulation activities. The final remedy contained in EPA's October, 1994 Record of Decision addressed remaining hazardous substances, primarily in the marine environment. The major marine components of the selected remedy included:

- Dredging of all soft bay mud from the Lauritzen Channel and Parr Canal, with offsite disposal of dredged material.

- Marine monitoring to verify the effectiveness of the remedy.

The first component of the remedy selected in the ROD called for dredging all "young bay mud" from those channels in Richmond Harbor which contained average DDT concentrations greater than 590 ppb (dry wt.). The dredging was completed in April, 1997. The short-term monitoring, performed according to EPA=s September 5, 1996 FSP, consisted of sediment chemistry monitoring to ensure that the average sediment concentration after dredging was below the cleanup level selected in the ROD. This monitoring was completed shortly prior to the placement of the sand cap in April, 1997. Subsequent monitoring has found some remaining contamination of surface sediment.

On March 14, 2002, divers from Battelle Marine Sciences collected sediment samples from 17 embankment and near shore locations along the eastern shore of the Lauritzen Channel. The piles supporting the Levin pier are numbered beginning at the northern end. The analytical results for one core, collected beneath the pier at Levin station 2.5 (i.e. between piles 2 and 3), indicated that it contained approximately 20,000,000 ppb (2%) DDT. The purpose of this sampling event was to attempt to confirm the very high level of contamination found at station 2.5 and delineate the area of high contamination.

FIELD NOTES AND OBSERVATIONS

1. Samples were collected near low tide using Geoprobe 2-inch cores with disposable acetate sleeves. The cores were lowered to the bottom by hand using 3-foot pipe sections, and then driven into the sediment with a small sledge hammer. The cores were retrieved and the sediment collected was transferred to paper buckets and then into 4 oz. glass sampling jars using dedicated plastic scoops. Samples were collected from areas of suspected lower contamination before moving to areas of suspected higher contamination. One embankment soil sample was (0702S19) collected by hand using a plastic scoop.

2. Table 1 contains the sample numbers, locations, depths and other information for the sediment samples collected on July 16 and 17, 2002. The line of piles at the northern edge of the Levin Pier is station 1. Levin=s station numbers are clearly maked with signs at the outside edge of the pier and have positive values. Locations to the north are determined by counting older and abandoned pile lines and are given negative values. The majority of sampling stations have half values (e.g. station 2.5) indicating that they are between pile lines. Distances listed in Table 1 are the approximate distance offshore from vertical sheet piling on the embankment. Depths were determined by the length of pipe used to reach the bottom prior to hammering the core into the sediment.

3. Samples were stored in a cooler with ice and transported by EPA staff to the Region 9 Laboratory for analysis of pesticides and PCBs under case number R02S28.

If you have any questions, please call me at (510) 412-2330.

Table 1. Sample Information

Sample ID	Date, Time	Station (Transect)	Distance	Depth	Remarks
0702S1	07/16/2002 13:50	- 4.5	10 ft.	13 ft.	mixture of YBM and OBM
0702S2-O	07/16/2002 13:55	-4.5	20 ft.	22 ft.	OBM
0702S2-Y	07/16/2002 13:55	-4.5	20 ft.	22 ft.	YBM (4 in. YBM over 0702S2-O)
0702S3	07/16/2002 14:05	-2.5	10 ft.	14 ft.	OBM at top of ~5 ft. vertical
0702S4	07/16/2002 14:10	-2.5	20 ft.	25 ft.	4 in. YBM over OBM
0702S5	07/16/2002 14:29	10.5	10 ft.	13 ft.	sandy YBM and OBM
0702S6	07/16/2002 14:38	10.5	20 ft.	23 ft.	
0702S7	07/16/2002 14:53	8.5	10 ft.	7 ft.	OBM w/rocks
0702S8	07/16/2002 15:19	8.5	20 ft.	23 ft.	YBM w/rocks
0702S8A	07/17/2002 11:15	6.5	10 ft.	6 ft.	OBM
0702S9	07/17/2002 11:24	6.5	20 ft.	20 ft.	YBM w/grit
0702S10	07/17/2002 12:04	4.5	10 ft.	9 ft.	mostly OBM
0702S11	07/17/2002 12:17	4.5	20 ft.	20 ft.	YBM w/rocks
0702S12	07/17/2002 12:32	3.5	20 ft.	17 ft.	YBM and OBM w/rocks
0702S13	07/17/2002 12:42	2.5	10 ft.	10 ft.	
0702S14	07/17/2002 13:10	2.5	20 ft.	16 ft.	very rocky, difficult to collect
0702S15	07/17/2002 13:20	2	20 ft.	19 ft.	YBM w/pebbles and grit
0702S16	07/17/2002 13:36	2	10 ft.	8 ft.	OBM grey/brown
0702S17	07/17/2002 13:53	1.5	20 ft.	13 ft.	primarily sand
0702S18	07/17/2002 13:58	1.5	20 ft.	13 ft.	duplicate of 0702S17
0702S19	07/17/2002 14:11	8.5	0 ft.	4 ft. bgs	light-colored embankment soil

APPENDIX C

OUTFALL, CORE, AND BANK SEDIMENT CHEMISTRY

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX LABORATORY
1337 S. 46TH STREET
BLDG. 201
RICHMOND, CA 94804-4698

APR 1 2 2002

MEMORANDUM

SUBJECT: Case R02S28
Results for Organochlorine Pesticides and PCBs Analyses

FROM: Brenda Bettencourt, Director
EPA Region 9 Laboratory (PMD-2)

TO: Carmen White, Remedial Project Manager
Superfund Air Force and DOE Section (SFD-8-1)

Attached are the report narratives and results spreadsheets from analysis of samples from the United Heckathorn Superfund site. These data have been reviewed in accordance with EPA Region 9 Laboratory policy. Summary information for the data included in this report is as follows:

SITE/PROJECT:	United Heckathorn
CASE:	R02S28
LABORATORY:	U. S. EPA Region 9 Laboratory
SAMPLE DELIVERY GROUP(S):	02038B
ANALYSIS:	Pesticides/PCBs (EPA methods 3545/8081)

A full documentation package for these data, including raw data and sample custody documentation, is on file at the EPA Region 9 Laboratory. If you would like to request additional review and/or validation of the data, please contact Vance Fong at the Region 9 Quality Assurance Office.

If you have any questions please contact Rich Bauer at (510) 412-2312, or Ken Hendrix at (510) 412-2321.

ATTACHMENT: Analytical Report

cc: Andy Lincoff, Region 9 Laboratory

USEPA REGION 9 LABORATORY
REPORT NARRATIVE

CASE NUMBER:	**R02S28**
SAMPLE DELIVERY GROUP (SDG):	**02038B**
PROGRAM:	**Superfund**
DOCUMENT CONTROL #:	**B0101069-1291**
ANALYSIS PERFORMED:	**Organochlorine Pesticides/PCBs**
DATE:	**March 26, 2002**
SAMPLE NUMBERS:	

Client Sample ID	Laboratory Sample ID
S-1	AB34174
S-2	AB34175
S-3	AB34176
S-4	AB34177
S-5	AB34178

GENERAL COMMENTS

Five (5) sediment samples from the United Heckathorn site for determination of pesticides/polychlorinated biphenyls (PCBs) were received at the EPA Region 9 Laboratory on 02/07/02.

These samples were analyzed for pesticides/PCBs in accordance with the Region 9 Laboratory SOP 330, *Organochlorine Pesticides and PCBs by GC* based on EPA SW-846 Method 8081A, *Organochlorine Pesticides by Gas Chromatography*, Revision 1, December 1996 and EPA SW-846 Method 8082, *Polychlorinated Biphenyls (PCBs) by Gas Chromatography*, Revision 0, December 1996.

Sample results are reported on a dry-weight basis.

SAMPLE RECEIPT AND PRESERVATION

The cooler temperatures associated with the samples in the table below were outside of the 2 - 6°C recommended temperature range when received. The samples were received less than four hours after collection and therefore did not have enough time to reach the recommended temperature. No significant impact on sample results is expected due to the minor temperature deviation.

Sample ID	Lab ID	Date Received	Temperature
S-1	AB34174	02/07/02	15°C
S-2	AB34175	02/07/02	15°C
S-3	AB34176	02/07/02	15°C
S-4	AB34177	02/07/02	15°C
S-5	AB34178	02/07/02	15°C

QA/QC AND ANALYTICAL COMMENTS

The following comments appear on the Summary of Analytical Results:

A. Results detected at concentrations below the quantitation limit (QL) but greater than or equal to one half the QL are reported with a "J" flag to indicate the uncertainty of quantitation at these levels.

B. The surrogates listed below do not meet QC limits. Quantitation limits for the analytes in the samples listed below are estimated and "J" flagged.

Sample ID	Lab ID	Surrogate	% Rec (Col. 1)	% Rec (Col. 2)	QC Limit
S-1	AB34174	Decachlorobiphenyl	150	NA	70 - 130
S-2	AB34175	Tetrachloro-m-xylene	52	50	70 - 130
S-2	AB34175	Decachlorobiphenyl	170	63	70 - 130
S-3	AB34176	Tetrachloro-m-xylene	67	NA	70 - 130

NA: Not Applicable, Value within QC limits

C. The accuracy of the LFB spiking compounds listed below does not meet the QC limits. Quantitation limits for the analytes listed below in sample AB34176 (S-3) which was extracted with the are estimated and flagged "J" due to the low percent recoveries.

LFB ID	Date Analyzed	Compound	% Rec	QC Limit
PBLK063	03/06/02	Aldrin	68	70 - 130
PBLK063	03/06/02	Lindane	66	70 - 130

D. The accuracy and precision of the LFM/LFMD spiking compounds listed below do not meet the QC limits. It should be noted that similar matrix effects may be present in samples of similar composition to the QC sample. Results for Dieldrin in sample AB34178 (S-5) are estimated and flagged "J".

Sample ID	Lab ID	Analyte	LFM % Rec	LFMD % Rec	QC Limit	RPD	QC Limit
S-3	AB34176	Dieldrin	–	274	65 - 135	118	25

– Value within QC limits

N. The sample concentration reported on each of the two analytical columns varied by more than 40% which indicate sample matrix interferences. The presence of the target analyte should therefore be deemed presumptive.

Additional QC comments:

QC requirements were met for all initial calibrations.

QC requirements were met for all CVs.

QC limits were met for all QCS percent differences, surrogate percent recoveries, LFB percent recoveries, LFM/LFMD (QC sample: AB34178, S-5) percent recoveries and RPDs, and QLS percent recoveries, except as noted above.

All samples were extracted within the 14 day holding time for soil samples and analyzed within the 40 day extract holding time.

No target analytes were detected in the LRBs associated with these samples.

Any questions in reference to this data package may be addressed to Ziyad Rajabi at (510) 412-2390.

GLOSSARY

Initial Calibration
The initial calibration demonstrates that the instrument has a linear calibration curve described by percent relative standard deviation (%RSD). The average calibration factors (CFs) determined in the initial calibration are used to quantitate analytes and surrogates.

Quality Control Standard (QCS)
The quality control standard is a mid-point calibration standard prepared from a source different than the calibration standards. The QCS is used to check the accuracy of the initial calibration standards.

Calibration Verification (CV)
The calibration verification checks the instrument performance daily by ensuring the instrument continues to meet the linear calibration curve as demonstrated by percent difference (%D).

Quantitation Limit Standard (QLS)
The quantitation limit standard is used to demonstrate low level quantitation performance for all target compounds.

Laboratory Reagent Blanks (LRBs)
A laboratory reagent blank is laboratory reagent water or baked sand with all reagents, surrogates, and internal standards added and carried through the same sample preparation and analytical procedures as the field samples. The LRB is used to determine the level of contamination introduced by the laboratory during extraction and analysis.

Surrogates
Surrogates are organic compounds which are similar to the target analytes in chemical composition and behavior in the analytical process, but which are not normally found in environmental samples. All samples are spiked with surrogate compounds prior to extraction. Surrogate percent recovery (%R) provides information about both the laboratory performance on individual samples and the possible effects of the sample matrix on the analytical results.

Laboratory Fortified Sample Matrix and Duplicate (LFM and LFMD) Analysis
Laboratory fortified sample matrix and duplicate analyses provide information about the effect of the sample matrix on sample preparation and measurement. Poor percent recovery (%R) results and large relative percent difference (RPD) between duplicates may indicate inconsistent laboratory technique, sample nonhomogeneity in soils, or matrix effects which may interfere with analysis.

Laboratory Fortified Blank (LFB) Analysis
A laboratory fortified blank is laboratory reagent water or baked sand with all reagents, surrogates, internal standards and representative target compounds added and carried through the same sample preparation and analytical procedures as the field samples. The LFB analyses provide information about the laboratory and method performance. Poor percent recovery (%R) results may indicate poor laboratory technique or poor method performance for a particular class of compounds.

Case: R02S28
Site: United Heckathorn
SDG: 02038B
Date: 3/27/02
Analysis: Pesticdes/PCB
Matrix: Soil

EPA REGION 9 - LABORATORY - RICHMOND, CA
SUMMARY OF ANALYTICAL RESULTS

Sample No.	S-1			S-2			S-3			S-4			S-5		
Lab Sample ID	AB34174			AB34175			AB34176			AB34177			AB34178		
Date of Collection	2/6/02			2/6/02			2/6/02			2/6/02			2/6/02		
% Solid	47			18			68			47			80		
Units	ug/kg			ug/kg			ug/kg			ug/kg			ug/kg		
Analyte	Result	Q	Cmt	Result	Q	Cmt	Result	Q	Cmt	Result	Q	Cmt	Result	Q	Cmt
alpha-BHC	200	UJ	B	50	UJ	B	10	UJ	B	20	U		10	U	
gamma-BHC	200	UJ	B	50	UJ	B	10	UJ	BC	20	U		10	U	
beta-BHC	100	JN	AB	40	J	AB	10	UJ	B	20	U		10	U	
delta-BHC	200	UJ	B	50	UJ	B	10	UJ	B	20	U		10	U	
Heptachlor	200	UJ	B	50	UJ	B	10	UJ	B	20	U		10	U	
Aldrin	200	UJ	B	40	J	AB	7	J	ABC	20	U		20		
Heptachlor epoxide	200	UJ	B	50	UJ	B	10	UJ	B	20	U		10	U	
2,4'-DDE	400	UJ	B	100	JN	B	20	UJ	B	40	U		20	JN	
gamma-Chlordane	200	UJ	B	200	J	B	8	J	AB	20	U		5	J	A
alpha-Chlordane	200	UJ	B	90	JN	BN	5	JN	AB	20	U		10	U	
4,4'-DDE	400	UJ	B	600	J	B	60	J	B	40	U		60		
Endosulfan I	200	UJ	B	30	JN	AB	10	UJ	B	20	U		10	U	
2,4'-DDD	400	UJ	B	2200	J	B	80	J	B	40	U		20	JN	A
Dieldrin	400	UJ	B	2800	J	B	120	J	BD	200			70	JN	
2,4'-DDT	400	UJ	B	500	J	B	340	J	B	30	J	A	80		
Endrin	400	UJ	B	12000	J		20	UJ	B	40	U		40		
4,4'-DDD	300	J	AB	3300	J	B	120	J	B	40	J	A	40	JN	
Endosulfan II	400	UJ	B	80	J	AB	20	UJ	B	40	U		20	U	
4,4'-DDT	400	UJ	B	2000	J	B	680	J	B	80			500	JN	
Endrin aldehyde	400	UJ	B	200	JN	B	20	UJ	B	40	U		70	JN	
Methoxychlor	2000	UJ	B	500	UJ	B	100	UJ	B	200	U		100	U	
Endosulfan sulfate	400	UJ	B	100	UJ	B	20	UJ	B	40	U		20	J	A
Endrin ketone	400	UJ	B	5000	J	B	20	UJ	B	40	U		20	U	
Toxaphene	20000	UJ	B	5000	UJ	B	1000	UJ	B	2000	U		1000	U	
Aroclor 1016	4000	UJ	B	1000	UJ	B	200	UJ	B	400	U		200	U	
Aroclor 1221	8000	UJ	B	2000	UJ	B	400	UJ	B	800	U		400	U	
Aroclor 1232	4000	UJ	B	1000	UJ	B	200	UJ	B	400	U		200	U	
Aroclor 1242	4000	UJ	B	1000	UJ	B	200	UJ	B	400	U		200	U	
Aroclor 1248	4000	UJ	B	1000	UJ	B	200	UJ	B	400	U		200	U	
Aroclor 1254	5900	J	B	1000	UJ	B	200	UJ	B	400	U		200	U	
Aroclor 1260	4000	UJ	B	1000	UJ	B	200	UJ	B	400	U		7000	J	A

Results are reported on a Dry-Weight Basis

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION IX LABORATORY
1337 S. 46TH STREET
BLDG. 201
RICHMOND, CA 94804-4698

MAY 1 4 2002

MEMORANDUM

SUBJECT: Case R02S28
Results for Organochlorine Pesticides and PCBs Analyses

FROM: Brenda Bettencourt, Director
EPA Region 9 Laboratory (PMD-2)

TO: Carmen White, Remedial Project Manager
Federal Facility Section 1 (SFD-8-1)

Attached are the report narratives and results spreadsheets from analysis of samples from the United Heckathorn Superfund site. These data have been reviewed in accordance with EPA Region 9 Laboratory policy. Summary information for the data included in this report is as follows:

SITE/PROJECT:	United Heckathorn
CASE:	R02S28
LABORATORY:	U. S. EPA Region 9 Laboratory
SAMPLE DELIVERY GROUP(S):	02073A
ANALYSIS:	Pesticides/PCBs (EPA methods 3545/8081)

A full documentation package for these data, including raw data and sample custody documentation, is on file at the EPA Region 9 Laboratory. If you would like to request additional review and/or validation of the data, please contact Vance Fong at the Region 9 Quality Assurance Office.

If you have any questions please contact Rich Bauer at (510) 412-2312, or Ken Hendrix at (510) 412-2321.

ATTACHMENT: Analytical Report

cc: Andy Lincoff, Region 9 Laboratory

USEPA REGION 9 LABORATORY
REPORT NARRATIVE

CASE NUMBER: R02S28
SAMPLE DELIVERY GROUP (SDG): 02073A
PROGRAM: Superfund
DOCUMENT CONTROL #: B0101069-1422
ANALYSIS PERFORMED: Organochlorine Pesticides/PCBs
DATE: May 7, 2002
SAMPLE NUMBERS:

Client Sample ID	Laboratory Sample ID	Client Sample ID	Laboratory Sample ID
T(-0.5)C1	AB34607	T(-0.5)B	AB34636
Y FILTER-8	AB34627	T(-4.5)B	AB34637
T(+55.5)C1	AB34628	T(-19.5)B	AB34638
T(+39.5)C1	AB34629	T(-32.5)B	AB34639
T(+23.5)C1	AB34630	Y STRAINER-48	AB34640
T(+11.5)C1	AB34631	T(+2.5)B	AB34641
T(-4.5)C1	AB34632	T(-12.5)B	AB34642
T(-12.5)C1	AB34633	T(+11.5)B	AB34643
T(2.5)C1	AB34634	T(+31.5)B	AB34644
T(-24.5)C1	AB34635		

GENERAL COMMENTS

Nineteen (19) sediment samples from the United Heckathorn site for determination of organochlorine pesticides were received at the EPA Region 9 Laboratory on 03/14/02 and 03/15/02.

All samples were analyzed for in accordance with the Region 9 Laboratory SOP 330, *Organochlorine Pesticides and PCBs by GC* based on EPA SW-846 Method 8081A. Additional analytes were added specifically for this project. All samples were screened for polychlorinated biphenyls; none were defected.

All sample results are reported on a dry-weight basis except for sample Y Filter-8 (AB34627). An insufficient amount of Y Filter-8 sample was available for moisture determination.

SAMPLE RECEIPT AND PRESERVATION

No shipping or preservation issues were encountered with these samples.

QA/QC AND ANALYTICAL COMMENTS

The following comments appear on the Summary of Analytical Results:

A. Results detected at concentrations below the quantitation limit (QL) but greater than or equal to one half the QL are reported with a "J" flag to indicate the uncertainty of quantitation at these levels.

B. The analytes listed below exceeded the CV %D QC limits. Detected results for these analytes in the samples and LRB associated with this CV are estimated and "J" flagged.

Std Filename	Instrument	Date	Analyte	%D (Col 1)	%D (Col 2)	QC Limit
088C039	HP6890-2	03/30/02	Heptachlor	--	-33	±20
093C022	HP6890-2	04/03/02	Heptachlor	--	-24	±20
093C043	HP6890-2	04/04/02	Endosulfan I	-21	--	±20

C. The surrogates listed below do not meet QC limits. Results and quantitation limits for the analytes in the samples listed below are estimated and "J" flagged.

Sample ID	Lab ID	Surrogate	% Rec (Col. 1)	% Rec (Col. 2)	QC Limit
T(-0.5)C1	AB34607	Tetrachloro-m-xylene	--	66	70 - 130
Y Filter -8	AB34627	Tetrachloro-m-xylene	53	57	70 - 130
Y Filter -8	AB34627	Decachlorobiphenyl	--	63	70 - 130
T(+55.5)C1	AB34628	Tetrachloro-m-xylene	133	65	70 - 130
T(+39.5)C1	AB34629	Tetrachloro-m-xylene	142	67	70 - 130
T(+23.5)C1	AB34630	Decachlorobiphenyl	68	--	70 - 130
T(-24.5)C1	AB34635	Tetrachloro-m-xylene	154	62	70 - 130
Y Filter -8	AB34627DL	Tetrachloro-m-xylene	62	65	70 - 130
Y Filter -8	AB34627DL	Decachlorobiphenyl	--	69	70 - 130

N. The sample concentration reported on each of the two analytical columns varied by more than 40% which indicate sample matrix interferences. The presence of the target analyte should therefore be deemed presumptive.

Additional QC comments:

QC requirements were met for all initial calibrations.

QC requirements were met for all Cvs, except as noted above.

QC limits were met for all QCS percent differences, LFB percent recoveries, and QLS percent recoveries.

All samples were extracted within the 14 day holding time for soil samples and analyzed within the 40 day extract holding time.

Any questions in reference to this data package may be addressed to Ziyad Rajabi at (510) 412-2390.

GLOSSARY

Initial Calibration
The initial calibration demonstrates that the instrument has a linear calibration curve described by percent relative standard deviation (%RSD). The average calibration factors (CFs) determined in the initial calibration are used to quantitate analytes and surrogates.

Quality Control Standard (QCS)
The quality control standard is a mid-point calibration standard prepared from a source different than the calibration standards. The QCS is used to check the accuracy of the initial calibration standards.

Calibration Verification (CV)
The calibration verification checks the instrument performance daily by ensuring the instrument continues to meet the linear calibration curve as demonstrated by percent difference (%D).

Quantitation Limit Standard (QLS)
The quantitation limit standard is used to demonstrate low level quantitation performance for all target compounds.

Laboratory Reagent Blanks (LRBs)
A laboratory reagent blank is laboratory reagent water or baked sand with all reagents, surrogates, and internal standards added and carried through the same sample preparation and analytical procedures as the field samples. The LRB is used to determine the level of contamination introduced by the laboratory during extraction and analysis.

Surrogates
Surrogates are organic compounds which are similar to the target analytes in chemical composition and behavior in the analytical process, but which are not normally found in environmental samples. All samples are spiked with surrogate compounds prior to extraction. Surrogate percent recovery (%R) provides information about both the laboratory performance on individual samples and the possible effects of the sample matrix on the analytical results.

Laboratory Fortified Sample Matrix and Duplicate (LFM and LFMD) Analysis
Laboratory fortified sample matrix and duplicate analyses provide information about the effect of the sample matrix on sample preparation and measurement. Poor percent recovery (%R) results and large relative percent difference (RPD) between duplicates may indicate inconsistent laboratory technique, sample nonhomogeneity in soils, or matrix effects which may interfere with analysis.

Laboratory Fortified Blank (LFB) Analysis
A laboratory fortified blank is laboratory reagent water or baked sand with all reagents, surrogates, internal standards and representative target compounds added and carried through the same sample preparation and analytical procedures as the field samples. The LFB analyses provide information about the laboratory and method performance. Poor percent recovery (%R)

results may indicate poor laboratory technique or poor method performance for a particular class of compounds.

Suffixes to Sample ID and Lab ID

The following suffixes may be attached to sample ID's and lab ID's to distinguish between different extraction samples or analytical runs: RX for re-extraction, RE for re-analysis, and DL for dilution analysis.

EPA REGION 9 - LABORATORY - RICHMOND, CA
SUMMARY OF ANALYTICAL RESULTS

Case: R02S28
Site: United Heckathorn
SDG: 02073A
Date: 3/27/02
Analysis: Pesticdes/PCB
Matrix: Soil

Sample No.	T(-0.5)C1			Y FILTER-8			T(+55.5)C1			T(+39.5)C1			T(+23.5)C1		
Lab Sample ID	AB34607			AB34627			AB34628			AB34629			AB34630		
Date of Collection	3/13/02			3/14/02			3/14/02			3/14/02			3/14/02		
Moisture, %	40			NA			53			39			33		
Units	ug/Kg			ug/Kg			ug/Kg			ug/Kg			ug/Kg		
Analyte	Result	Q	Cmt	Result	Q	Cmt	Result	Q	Cmt	Result	Q	Cmt	Result	Q	Cmt
alpha-BHC	10	UJ	C	10	UJ	C	20	UJ	C	20	UJ	C	10	UJ	C
gamma-BHC	10	UJ	C	10	UJ	C	20	UJ	C	20	UJ	C	10	UJ	C
beta-BHC	10	UJ	C	10	UJ	C	40	J	CN	20	UJ	C	10	UJ	C
delta-BHC	10	J	C	10	UJ	C	20	UJ	C	20	UJ	C	10	UJ	C
Heptachlor	10	UJ	C	10	UJ	C	20	UJ	C	20	UJ	C	10	UJ	C
Aldrin	20	J	C	10	UJ	C	20	UJ	C	20	UJ	C	10	UJ	C
Heptachlor epoxide	10	UJ	C	10	UJ	C	20	UJ	C	20	UJ	C	10	UJ	C
2,4'-DDE	30	J	CN	20	UJ	C	50			30	J	C	20	J	AC
gamma-Chlordane	30	J	CN	7	J	AC	20	UJ	C	20	UJ	C	10	UJ	C
alpha-Chlordane	20	J	C	10	UJ	C	10	J	CAN	20	UJ	C	10	UJ	C
4,4'-DDE	200	J	C	30	J	C	200	J	CN	60	J	C	60	J	C
Endosulfan I	30	UJ	C	20	UJ	C	40	UJ	C	30	UJ	C	20	UJ	C
2,4'-DDD	1,000			100	J	C	200	J	C	80	J	C	60	J	C
Dieldrin	200	J	C	100	J	C	60	J	C	20	J	AC	20	J	C
2,4'-DDT	800			70	J	C	20	J	AC	200	J	C	60	J	C
Endrin	40	J	CN	600	J	C	40	UJ	C	30	UJ	C	20	UJ	C
4,4'-DDD	3,500			100	J	C	1,100	J	C	320	J	C	200	J	C
Endosulfan II	30	UJ	C	20	UJ	C	40	UJ	C	30	UJ	C	20	UJ	C
4,4'-DDT	5,200			200	J	C	200	J	C	2,000			860		
Endrin aldehyde	30	UJ	C	10	J	AC	40	UJ	C	30	UJ	C	20	UJ	C
Methoxychlor	100	UJ	C	60	J	AC	200	UJ	C	200	UJ	C	100	UJ	C
Endosulfan sulfate	30	UJ	C	20	UJ	C	40	UJ	C	30	UJ	C	20	UJ	C
Endrin ketone	30	UJ	C	200	J	C	40	UJ	C	30	UJ	C	20	UJ	C
Toxaphene	1,000	UJ	C	1,000	UJ	C	2,000	UJ	C	2,000	UJ	C	1,000	UJ	C
Aroclor 1016	300	UJ	C	200	UJ	C	400	UJ	C	300	UJ	C	200	UJ	C
Aroclor 1221	600	UJ	C	500	UJ	C	800	UJ	C	600	UJ	C	500	UJ	C
Aroclor 1232	300	UJ	C	200	UJ	C	400	UJ	C	300	UJ	C	200	UJ	C
Aroclor 1242	300	UJ	C	200	UJ	C	400	UJ	C	300	UJ	C	200	UJ	C
Aroclor 1248	300	UJ	C	200	UJ	C	400	UJ	C	300	UJ	C	200	UJ	C
Aroclor 1254	300	UJ	C	200	UJ	C	400	UJ	C	300	UJ	C	200	UJ	C
Aroclor 1260	300	UJ	C	200	UJ	C	400	UJ	C	300	UJ	C	200	UJ	C

NA=Not Analyzed
Results reported on a dry-weight basis

C.13

EPA REGION 9 - LABORATORY - RICHMOND, CA
SUMMARY OF ANALYTICAL RESULTS

Case: R02S28
Site: United Hecl
SDG: 02073A
Date: 3/27/02
Analysis: Pesticdes/Pt
Matrix: Soil

Sample No.	T(+11.5)C1			T(-4.5)C1			T(-12.5)C1			T(2.5)C1			T(-24.5)C1		
Lab Sample ID	AB34631			AB34632			AB34633			AB34634			AB34635		
Date of Collection	3/14/02			3/14/02			3/14/02			3/14/02			3/14/02		
Moisture, %	42			43			25			34			48		
Units	ug/Kg			ug/Kg			ug/Kg			ug/Kg			ug/Kg		
Analyte	Result	Q	Cmt	Result	Q	Cmt	Result	Q	Cmt	Result	Q	Cmt	Result	Q	Cmt
alpha-BHC	20	U		20	U		10	U		500			20	UJ	C
gamma-BHC	20	U		20	U		10	U		30			20	UJ	C
beta-BHC	20	J	N	20	U		10	U		40			40	J	C
delta-BHC	20	U		20	U		10	U		200			20	UJ	C
Heptachlor	20	U		20	U		10	U		80			20	UJ	C
Aldrin	20	U		50			20			8,000			20	UJ	C
Heptachlor epoxide	20	U		20	U		10	U		10	U		20	UJ	C
2,4'-DDE	40	J	N	80	J	N	20	J	A	10,000			40	J	CN
gamma-Chlordane	20	U		50	J	N	7	J	AN	300	J	N	60	J	CN
alpha-Chlordane	20	U		40	J	N	10	U		300	J	N	20	J	CN
4,4'-DDE	350			600			100			130,000			370		
Endosulfan I	30	U		30	U		20	U		30	U		40	UJ	C
2,4'-DDD	480			1,000			300			150,000			1,000		
Dieldrin	90			800			70			50,000			200	J	C
2,4'-DDT	2,000			1,000			800			3,000,000			200	J	CN
Endrin	30	U		40			20	U		1,000			40	UJ	C
4,4'-DDD	2,000			3,000			1,000			900,000			4,300		
Endosulfan II	30	U		30	U		20	U		4,000	J	N	40	UJ	C
4,4'-DDT	12,000			4,700			3,700			19,000,000			3,000		
Endrin aldehyde	30	U		30	U		20	U		200			40	UJ	C
Methoxychlor	200	U		200	U		100	U		100	U		200	UJ	C
Endosulfan sulfate	30	U		30	U		20	U		30	U		40	UJ	C
Endrin ketone	30	U		30	U		20	U		1,000			40	UJ	C
Toxaphene	2,000	U		2,000	U		1,000	U		1,000	U		2,000	UJ	C
Aroclor 1016	300	U		300	U		200	U		300	U		400	UJ	C
Aroclor 1221	600	U		600	U		500	U		500	U		700	UJ	C
Aroclor 1232	300	U		300	U		200	U		300	U		400	UJ	C
Aroclor 1242	300	U		300	U		200	U		300	U		400	UJ	C
Aroclor 1248	300	U		300	U		200	U		300	U		400	UJ	C
Aroclor 1254	300	U		300	U		200	U		300	U		400	UJ	C
Aroclor 1260	300	U		300	U		200	U		300	U		400	UJ	C

NA=Not Analyzed
Results reported on a dry-weig

EPA REGION 9 - LABORATORY - RICHMOND, CA
SUMMARY OF ANALYTICAL RESULTS

Case: R02S28
Site: United Hecl
SDG: 02073A
Date: 3/27/02
Analysis: Pesticdes/P(
Matrix: Soil

Sample No.	T(-0.5)B			T(-4.5)B			T(-19.5)B			T(-32.5)B			Y STRAINER - 48		
Lab Sample ID	AB34636			AB34637			AB34638			AB34639			AB34640		
Date of Collection	3/14/02			3/14/02			3/14/02			3/14/02			3/14/02		
Moisture, %	24			5			59			35			58		
Units	ug/Kg			ug/Kg			ug/Kg			ug/Kg			ug/Kg		
Analyte	Result	Q	Cmt	Result	Q	Cmt	Result	Q	Cmt	Result	Q	Cmt	Result	Q	Cmt
alpha-BHC	8	J	A	5	J	A	20	U		20	U		20	U	
gamma-BHC	10	U		5	J	A	20	U		20	U		20	U	
beta-BHC	20	J	N	100			20	U		20	U		100	J	N
delta-BHC	5	J	AN	10			20	U		20	U		20	U	
Heptachlor	60	J	B	320			20	J	B	50	J	B	20	U	
Aldrin	20			500			10	J	AN	60			30	J	N
Heptachlor epoxide	10	U		50	J	N	20	U		20	U		20	U	
2,4'-DDE	200			2,000			20	J	AN	400			80	J	N
gamma-Chlordane	80	J	N	2,000			20	J	AN	460			30	J	N
alpha-Chlordane	70	J	N	1,000	J	N	20	J	AN	200	J	N	20	J	N
4,4'-DDE	3,000			20,000			100			8,000			200	J	N
Endosulfan I	20	U		20	U		40	U		20	J	AN	20	J	AN
2,4'-DDD	2,000			9,000			200	J	N	2,000			100		
Dieldrin	2,000			12,000			200			6,000			40	J	AN
2,4'-DDT	7,000			46,000			70	J	N	7,000			80		
Endrin	60	J	N	2,900			40	J	A	3,000			40	U	
4,4'-DDD	3,000			20,000			1,000			3,000			300		
Endosulfan II	20	U		20	U		40	U		30	U		40	U	
4,4'-DDT	31,000			220,000			400	J	N	33,000			300	J	N
Endrin aldehyde	20	U		20	U		40	U		30	J	AN	100		
Methoxychlor	100	U		100	U		200	U		100	U		200	U	
Endosulfan sulfate	20	U		20	U		40	U		30	U		40	U	
Endrin ketone	20	J	N	200			40	J	N	3,600			40	U	
Toxaphene	1,000	U		1,000	U		2,000	U		1,000	U		2,000	U	
Aroclor 1016	300	U		200	U		400	U		300	U		400	U	
Aroclor 1221	500	U		400	U		900	U		600	U		900	U	
Aroclor 1232	300	U		200	U		400	U		300	U		400	U	
Aroclor 1242	300	U		200	U		400	U		300	U		400	U	
Aroclor 1248	300	U		200	U		400	U		300	U		400	U	
Aroclor 1254	300	U		200	U		400	U		300	U		400	U	
Aroclor 1260	300	U		200	U		400	U		300	U		400	U	

NA=Not Analyzed
Results reported on a dry-weig

EPA REGION 9 - LABORATORY - RICHMOND, CA
SUMMARY OF ANALYTICAL RESULTS

Case: R02S28
Site: United Hecl
SDG: 02073A
Date: 3/27/02
Analysis: Pesticdes/Pt
Matrix: Soil

Sample No.	T(+2.5)B			T(-12.5)B			T(+11.5)B			T(+31.5)B			Method Blank		
Lab Sample ID	AB34641			AB34642			AB34643			AB34644			PBLK078		
Date of Collection	3/14/02			3/14/02			3/14/02			3/14/02			NA		
Moisture, %	21			5			15			4			NA		
Units	ug/Kg			ug/Kg			ug/Kg			ug/Kg			ug/Kg		
Analyte	Result	Q	Cmt	Result	Q	Cmt	Result	Q	Cmt	Result	Q	Cmt	Result	Q	Cmt
alpha-BHC	20			7	J	A	10	U		10	U		10	U	
gamma-BHC	10			10	J	A	10	U		10	U		10	U	
beta-BHC	20	J	A	200			10	U		10	J	N	10	U	
delta-BHC	7	J	A	30	J	N	10	U		10	U		10	U	
Heptachlor	20	J	B	700			10	U		10	U		10	U	
Aldrin	20			2,000			10	U		10	U		10	U	
Heptachlor epoxide	10	U		100	J	N	10	U		6	J	A	10	U	
2,4'-DDE	600	J	A	4,000			80			30	J	N	20	U	
gamma-Chlordane	100	J	N	2,000			10	U		30			10	U	
alpha-Chlordane	80	J	N	1,000	J	N	10	U		20	J	N	10	U	
4,4'-DDE	13,000			30,000			2,000			230			20	U	
Endosulfan I	20	U		20	U		20	U		20	U		20	U	
2,4'-DDD	3,000			16,000			60			80	J	N	20	U	
Dieldrin	1,000	J	A	14,000			20	J	N	50	J	N	20	U	
2,4'-DDT	30,000			50,000			3,000			280			20	U	
Endrin	50	J	N	9,000			20	J	A	200	J		20	U	
4,4'-DDD	7,000			30,000			200			200			20	U	
Endosulfan II	20	U		20	U		20	U		20	U		20	U	
4,4'-DDT	160,000			240,000			27,000			2,000	J		20	U	
Endrin aldehyde	20	U		20	U		20	U		20	U		20	U	
Methoxychlor	100	U		300	J	N	100	U		100	U		100	U	
Endosulfan sulfate	20	U		20	U		20	U		20	U		20	U	
Endrin ketone	20	J	N	2,000			20	U		50			20	U	
Toxaphene	1,000	U		1,000	U		1,000	U		1,000	U		1,000	U	
Aroclor 1016	200	U		200	U		200	U		200	U		200	U	
Aroclor 1221	500	U		400	U		400	U		400	U		400	U	
Aroclor 1232	200	U		200	U		200	U		200	U		200	U	
Aroclor 1242	200	U		200	U		200	U		200	U		200	U	
Aroclor 1248	200	U		200	U		200	U		200	U		200	U	
Aroclor 1254	200	U		200	U		200	U		200	U		200	U	
Aroclor 1260	200	U		200	U		200	U		200	U		200	U	

NA=Not Analyzed
Results reported on a dry-weig

EPA REGION 9 - LABORATORY - RICHMOND, CA
SUMMARY OF ANALYTICAL RESULTS

Case: R02S28
Site: United Hecl
SDG: 02073A
Date: 3/27/02
Analysis: Pesticdes/P(
Matrix: Soil

Sample No.	Method Blank		
Lab Sample ID	PBLK084		
Date of Collection	NA		
Moisture, %	NA		
Units	ug/Kg		
Analyte	Result	Q	Cmt
alpha-BHC	10	U	
gamma-BHC	10	U	
beta-BHC	10	U	
delta-BHC	10	U	
Heptachlor	10	U	
Aldrin	10	U	
Heptachlor epoxide	10	U	
2,4'-DDE	20	U	
gamma-Chlordane	10	U	
alpha-Chlordane	10	U	
4,4'-DDE	20	U	
Endosulfan I	20	U	
2,4'-DDD	20	U	
Dieldrin	20	U	
2,4'-DDT	20	U	
Endrin	20	U	
4,4'-DDD	20	U	
Endosulfan II	20	U	
4,4'-DDT	20		
Endrin aldehyde	20	U	
Methoxychlor	100	U	
Endosulfan sulfate	20	U	
Endrin ketone	20	U	
Toxaphene	1,000	U	
Aroclor 1016	200	U	
Aroclor 1221	400	U	
Aroclor 1232	200	U	
Aroclor 1242	200	U	
Aroclor 1248	200	U	
Aroclor 1254	200	U	
Aroclor 1260	200	U	

NA=Not Analyzed
Results reported on a dry-weig

C.17

USEPA REGION 9 LABORATORY

REPORT NARRATIVE

CASE NUMBER:	**R02S28**
SAMPLE DELIVERY GROUP (SDG):	**02199D**
PROGRAM:	**Superfund**
DOCUMENT CONTROL #:	**B0101117-1816**
ANALYSIS PERFORMED:	**Organochlorine Pesticides/PCBs August 16, 2002**

SAMPLE NUMBERS:

Client Sample ID	Laboratory Sample ID
0702-S1	AB36116
0702-S2-OLD	AB36117
0702-S2-Y	AB36118
0702-S3	AB36119
0702-S4	AB36120
0702-S5	AB36121
0702-S6	AB36122
0702-S7	AB36123
0702-S8	AB36124
0702-S8-A	AB36125
0702-S9	AB36126

Client Sample ID	Laboratory Sample ID
0702-S10	AB36127
0702-S11	AB36128
0702-S12	AB36129
0702-S13	AB36130
0702-S14	AB36131
0702-S15	AB36132
0702-S16	AB36133
0702-S17	AB36134
0702-S18	AB36135
0702-S19	AB36136

GENERAL COMMENTS

Twenty-one (21) soil samples from the United Heckathorne site for determination of pesticides/polychlorinated biphenyls (PCB's) were received at the EPA Region 9 Laboratory on 7/17/200.

These samples were analyzed for pesticides/PCB's in accordance with the Region 9 Laboratory SOP 330, *Organochlorine Pesticides and PCB's by GC* based on EPA SW-846 Method 8081A, *Organochlorine Pesticides by Gas Chromatography*, Revision 1, December 1996 and EPA SW-846 Method 8082, *Polychlorinated Biphenyls (PCBs) by Gas Chromatography*, Revision 0, December 1996. A reduced sample size of 5 g (instead of 30 g) was used for all of the samples because of expected high concentrations of target analytes. The QL's were raised accordingly.

Sample results are reported on a dry-weight basis.

SAMPLE RECEIPT AND PRESERVATION

No shipping or preservation issues were encountered with these samples.

QA/QC AND ANALYTICAL COMMENTS

The following comments appear on the Summary of Analytical Results:

I. Results detected at concentrations below the quantitation limit (QL) but greater than or equal to one half the QL are reported with a "J" flag to indicate the uncertainty of quantitation at these levels.

A. The surrogates listed below do not meet QC limits. Results and quantitation limits for the analytes in the samples listed below are estimated and "J" flagged.

Sample ID	Lab ID	Surrogate	% Rec (Col. 1)	% Rec (Col. 2)	QC Limit
0702-S4	AB36120	Tetrachloro-m-xylene	61	62	70 - 130
0702-S6	AB36122	Tetrachloro-m-xylene l	160	--	70 - 130
0702-S6	AB36122	Decachlorobiphenyl	--	164	70 - 130
0702-S8	AB36124	Tetrachloro-m-xylene l	179	--	70 - 130
0702-S8	AB36124	Decachlorobiphenyl	--	196	70 - 130
0702-S11	AB36128	Tetrachloro-m-xylene	288	--	70 - 130
0702-S11	AB36128	Decachlorobiphenyl	--	166	70 - 130
0702-S15	AB36132	Tetrachloro-m-xylene	142	--	70 - 130

I. The accuracy of the LFB spiking compounds listed below does not meet the QC limits. Quantitation limits for the analytes listed below in samples and LRB extracted with the LFB listed below are estimated and "J" flagged due to the low percent recoveries.

LFB ID	Date Analyzed	Compound	% Rec	QC Limit
PBLK206	08/01/02	Aldrin	60	70 - 130
PBLK206	08/01/02	Lindane	60	70 - 130

I. The sample concentration reported on each of the two analytical columns varied by more than 40% which indicate sample matrix interferences. The presence of the target analyte should therefore be deemed presumptive.

II. The amount detected, which exceeds the calibration range of the instrument, is estimated and "J" flagged.

Additionally, the following QC results are associated with the samples in this SDG:

4,4'-DDT recoveries and RPD were not evaluated in LFM/LFMD QA samples (0702-S5 and 0702-S19) because the detected amount is over the linear calibration range.

QC limits were met for all initial calibrations, CVs, QCS percent differences, surrogate percent recoveries, LFB percent recoveries, LFM/LFMD (QC sample: 0702-S5 and 0702-S19) percent recoveries and RPDs, except as noted above.

All samples were extracted within the 14 day holding time for soil samples and analyzed within the 40 day extract holding time.

Any questions in reference to this data package may be addressed to Ziyad Rajabi at (510) 412-2390.

GLOSSARY

Initial Calibration
The initial calibration demonstrates that the instrument has a linear calibration curve described by percent relative standard deviation (%RSD). The average calibration factors (CFs) determined in the initial calibration are used to quantitate analytes and surrogates.

Quality Control Standard (QCS)
The quality control standard is a mid-point calibration standard prepared from a source different than the calibration standards. The QCS is used to check the accuracy of the initial calibration standards.

Calibration Verification (CV)
The calibration verification checks the instrument performance daily by ensuring the instrument continues to meet the linear calibration curve as demonstrated by percent difference (%D).

Quantitation Limit Standard (QLS)
The quantitation limit standard is used to demonstrate low level quantitation performance for all target compounds.

Laboratory Reagent Blanks (LRBs)
A laboratory reagent blank is laboratory reagent water or baked sand with all reagents, surrogates, and internal standards added and carried through the same sample preparation and analytical procedures as the field samples. The LRB is used to determine the level of contamination introduced by the laboratory during extraction and analysis.

Surrogates
Surrogates are organic compounds which are similar to the target analytes in chemical composition and behavior in the analytical process, but which are not normally found in environmental samples. All samples are spiked with surrogate compounds prior to extraction. Surrogate percent recovery (%R) provides information about both the laboratory performance on individual samples and the possible effects of the sample matrix on the analytical results.

Laboratory Fortified Sample Matrix and Duplicate (LFM and LFMD) Analysis
Laboratory fortified sample matrix and duplicate analyses provide information about the effect of the sample matrix on sample preparation and measurement. Poor percent recovery (%R) results and large relative percent difference (RPD) between duplicates may indicate inconsistent laboratory technique, sample nonhomogeneity in soils, or matrix effects which may interfere with analysis.

Laboratory Fortified Blank (LFB) Analysis
A laboratory fortified blank is laboratory reagent water or baked sand with all reagents, surrogates, internal standards and representative target compounds added and carried through the same sample preparation and analytical procedures as the field samples. The LFB analyses provide information about the laboratory and method performance. Poor percent recovery (%R) results may indicate poor laboratory technique or poor method performance for a particular class of compounds.

Suffixes to Sample ID and Lab ID
The following suffixes may be attached to sample ID's and lab ID's to distinguish between different extraction samples or analytical runs: RX for re-extraction, RE for re-analysis, and DL for dilution analysis.

DATA PACKAGE COMMENTS

The software places "m" flags on quantitation reports and enhanced chromatograms for non-manually integrated data whenever the software sums several peaks. This occurs for "total" Aroclor results.

Method 8081A recommends reporting the higher of two results obtained on two dissimilar GC columns because this is a conservative approach relative to protection of the environment. Laboratory procedure is to report the lower of the two results because interferences on one column is expected to yield a higher result for that column.

Example calculations:

4,4'-DDT concentration (signal #1) for sample AB36116 (0702-S1) using data file 212C015.D:

$$\text{Conc. g/Kg (dry-weight basis)} = \frac{A_x \times V_t \times DF \times GPC \times 1{,}000\ g/Kg}{RF \times W \times \%S \times V_i \times 1{,}000{,}000\ pg/g}$$

where:

- A_x = area sum response of the sample
- W = weight of sample in grams
- RF = mean response factor (area/pg) from the initial calibration of 07/30/02
- V_t = volume of concentrated extract in L
- DF = dilution factor
- %S =% Solids
- V_i = volume of extract injected in L
- GPC = GPC factor. (If no GPC is performed, GPC = 1. If GPC is performed, then GPC = 2.0

$$= \frac{3{,}243{,}400{,}000 \times 5{,}000\ L \times 2 \times 2 \times 1{,}000\ g/Kg}{24{,}480{,}000\ (pg^{-1}) \times 5.67\ g \times 0.78 \times 1\ L \times 1{,}000{,}000\ pg/g}$$

$$= 599 - 600\ \mu g/Kg$$

Decachlorobiphenyl surrogate % Recovery for sample AB36119 (0702-S3) using data file 212C036.D, signal #1:

$$\%\ Rec = \frac{A_x \times 100}{\text{Amount Spiked} \times RF}$$

where:

Amount Spiked = 200ng /(5mL final volume × 2 (GPC factor).

$$= \frac{355{,}100{,}000 \times 100}{20 \times 23{,}890{,}000}$$

= 74 % recovery

EPA REGION 9 - LABORATORY - RICHMOND, CA
SUMMARY OF ANALYTICAL RESULTS

Case: R02S28
Site: United Heckathorn
SDG: 02199D
Date: 08/14/02
Analysis: Pesticides/PCB
Matrix: Soil, ug/kg dry wt

Sample No.	0702-S1			0702-S2-OLD			0702-S2-Y			0702-S3			0702-S4			0702-S5		
Lab Sample ID	AB36116			AB36117			AB36118			AB36119			AB36120			AB36121		
Date of Collection	07/16/02			02/06/02			02/06/02			02/06/02			02/06/02			02/06/02		
Analyte	Result	Q	Cmt	Result	Q	Cmt	Result	Q	Cmt	Result	Q	Cmt	Result	Q	Cmt	Result	Q	Cmt
% Solid	78			75			68			73			55			69		
alpha-BHC	20	U		10	U		100	U		10	U		2000	U		100	U	
gamma-BHC	20	U		10	U		100	U		10	U		2000	UJ	C	100	U	
beta-BHC	20	U		10	U		100	U		10	U		2000	U		100	U	
delta-BHC	20	U		10	U		100	U		10	U		2000	U		100	U	
Heptachlor	20	U		10	U		100	U		10	U		2000	U		100	U	
Aldrin	20	U		10	U		100	U		10	U		2000	UJ	C	100	U	
Heptachlor epoxide	20	U		10	U		100	U		10	U		2000	U		100	U	
2,4'-DDE	40	U		20	U		300	U		20	U		4000	U		300	U	
gamma-Chlordane	20	U		10	U		100	U		10	U		2000	U		100	U	
alpha-Chlordane	20	U		10	U		100	U		10	U		2000	U		100	U	
4,4'-DDE	40	U		20	U		300	U		20			4000	U		300		
Endosulfan I	20	U		10	U		100	U		10	U		2000	U		100	U	
2,4'-DDD	60			10	U		200	J	A	60			3000	J	A	200	J	A
Dieldrin	20	J	A	20	U		300	U		10	J	A	3000	J	A	300	U	
2,4'-DDT	40			20	U		300	U		120			22000			300		
Endrin	40	U		20	U		300	U		20	U		4000	U		300	U	
4,4'-DDD	100			20			500			100			9000			600		
Endosulfan II	40	U		20	U		300	U		20	U		4000	U		300	U	
4,4'-DDT	600			30			2500			320			110000			2200		
Endrin aldehyde	40	U		20	U		300	U		20	U		4000	U		300	U	
Methoxychlor	200	U		100	U		1000	U		100	U		10000	U		1000	U	
Endosulfan sulfate	40	U		20	U		300	U		20	U		4000	U		300	U	
Endrin ketone	40	U		20	U		300	U		20	U		4000	U		300	U	
Toxaphene	2000	U		1000	U		10000	U		1000	U		100000	U		10000	U	
Aroclor 1016	400	U		200	U		2000	U		200	U		20000	U		2000	U	
Aroclor 1221	800	U		400	U		4000	U		400	U		40000	U		4000	U	
Aroclor 1232	400	U		200	U		2000	U		200	U		20000	U		2000	U	
Aroclor 1242	400	U		200	U		2000	U		200	U		20000	U		2000	U	
Aroclor 1248	400	U		200	U		2000	U		200	U		20000	U		2000	U	
Aroclor 1254	400	U		200	U		2000	U		200	U		20000	U		2000	U	
Aroclor 1260	400	U		200	U		2000	U		200	U		20000	U		2000	U	

Results are reported on a ug/kg Dry-Weight Basis

EPA REGION 9 - LABORATORY - RICHMOND, CA
SUMMARY OF ANALYTICAL RESULTS

Case: R02S28
Site: United Heckathorn
SDG: 02199D
Date: 08/14/02
Analysis: Pesticides/PCB
Matrix: Soil, ug/kg dry wt

Sample No.	0702-S6			0702-S7			0702-S8			0702-S8 A			0702-S9			0702-S10		
Lab Sample ID	AB36122			AB36123			AB36124			AB36125			AB36126			AB36127		
Date of Collection	02/06/02			02/06/02			02/06/02			02/06/02			02/06/02			02/06/02		
Analyte	Result	Q	Cmt	Result	Q	Cmt	Result	Q	Cmt	Result	Q	Cmt	Result	Q	Cmt	Result	Q	Cmt
% Solid	61			72			65			74			64			74		
alpha-BHC	100	U		100	U		200	U		20	U		2000	U		10	U	
gamma-BHC	100	U		100	U		200	U		20	U		2000	UJ	C	10	U	
beta-BHC	100	U		100	U		200	U		20	U		2000	U		10	U	
delta-BHC	100	U		100	U		200	U		20	U		2000	U		10	U	
Heptachlor	100	U		100	U		200	U		20	U		2000	U		10	U	
Aldrin	100	U		100	U		200	U		20	U		2000	UJ	C	10	U	
Heptachlor epoxide	100	U		100	U		200	U		20	U		2000	U		10	U	
2,4'-DDE	300	U		300	U		300	U		50	U		3000	U		20	U	
gamma-Chlordane	100	U		100	U		200	U		20	U		2000	U		10	U	
alpha-Chlordane	100	U		100	U		200	U		20	U		2000	U		10	U	
4,4'-DDE	500	J	B	300			400	J	B	50	U		3000	U		20		
Endosulfan I	100	U		100	U		200	U		20	U		2000	U		10	U	
2,4'-DDD	700	J	B	200	J	A	800	J	B	50	U		2000	J	A	30		
Dieldrin	200	J	AB	300	U		300	U		50	U		2000	U		20	U	
2,4'-DDT	1400	J	B	500			1000	J	B	140			3000			60		
Endrin	300	U		300	U		300	U		50	U		3000	U		20	U	
4,4'-DDD	2300	J	B	400			2600	J	B	90			5000			60		
Endosulfan II	300	U		300	U		300	U		50	U		3000	U		20	U	
4,4'-DDT	10000	J	B	2100			29000	J	B	600			29000			310		
Endrin aldehyde	300	U		300	U		300	U		50	U		3000	U		20	U	
Methoxychlor	1000	U		1000	U		1000	U		200	U		10000	U		100	U	
Endosulfan sulfate	300	U		300	U		300	U		50	U		3000	U		20	U	
Endrin ketone	300	U		300	U		300	U		50	U		3000	U		20	U	
Toxaphene	10000	U		10000	U		10000	U		2000	U		100000	U		1000	U	
Aroclor 1016	2000	U		2000	U		2000	U		400	U		20000	U		200	U	
Aroclor 1221	4000	U		4000	U		4000	U		800	U		40000	U		400	U	
Aroclor 1232	2000	U		2000	U		2000	U		400	U		20000	U		200	U	
Aroclor 1242	2000	U		2000	U		2000	U		400	U		20000	U		200	U	
Aroclor 1248	2000	U		2000	U		2000	U		400	U		20000	U		200	U	
Aroclor 1254	2000	U		2000	U		2000	U		400	U		20000	U		200	U	
Aroclor 1260	2000	U		2000	U		2000	U		400	U		2000	U		200	U	

Results are reported on a ug/kg Dry-We

EPA REGION 9 - LABORATORY - RICHMOND, CA
SUMMARY OF ANALYTICAL RESULTS

Case: R02S28
Site: United Heckathorn
SDG: 02199D
Date: 08/14/02
Analysis: Pesticides/PCB
Matrix: Soil, ug/kg dry wt

Sample No.	0702-S11			0702-S12			0702-S13			0702-S14			0702-S15			0702-S16		
Lab Sample ID	AB36128			AB36129			AB36130			AB36131			AB36132			AB36133		
Date of Collection	02/06/02			02/06/02			02/06/02			02/06/02			02/06/02			02/06/02		
Analyte	Result	Q	Cmt	Result	Q	Cmt	Result	Q	Cmt	Result	Q	Cmt	Result	Q	Cmt	Result	Q	Cmt
% Solid	77			78			73			75			62			76		
alpha-BHC	100	U		100	U		100	U		200			200	U		100	U	
gamma-BHC	100	U		100	U		100	U		100	U		200	U		100	U	
beta-BHC	100	U		100	U		100	U		100	U		200	U		100	U	
delta-BHC	100	U		100	U		100	U		100	U		200	U		100	U	
Heptachlor	100	U		100	U		100	U		100	U		200	U		100	U	
Aldrin	100	U		100	U		100	U		800			200	U		100	U	
Heptachlor epoxide	100	U		100	U		100	U		100	U		200	U		100	U	
2,4'-DDE	200	U		200			200	U		600			300	U		200	U	
gamma-Chlordane	100	U		100	U		100	U		100	U		200	U		100	U	
alpha-Chlordane	100	U		100	U		100	U		100	U		200	U		100	U	
4,4'-DDE	600	J	B	2400			200			10000			300	U		100	J	A
Endosulfan I	100	U		100	U		100	U		100	U		200	U		100	U	
2,4'-DDD	1600	J	B	8700			300			10000			400	J	B	300		
Dieldrin	400	J	B	1400			200	U		6500			300	U		200	U	
2,4'-DDT	2200	J	B	20000			3600			110000			800	J	B	900		
Endrin	200	U		200	J	D	200	U		500			300	U		200	U	
4,4'-DDD	5000	J	B	12000			900			60000			1100	J	B	1400		
Endosulfan II	200	U		200	U		200	U		200	U		300	U		200	U	
4,4'-DDT	25000	J	BE	120000			12000			1400000	J	E	6000	J	B	11000		
Endrin aldehyde	200	U		200	U		200	U		200	U		300	U		200	U	
Methoxychlor	1000	U		1000	U		1000	U		1000	U		1000	U		1000	U	
Endosulfan sulfate	200	U		200	U		200	U		200	U		300	U		200	U	
Endrin ketone	200	U		200	U		200	U		200	U		300	U		200	U	
Toxaphene	10000	U		10000	U		10000	U		10000	U		10000	U		10000	U	
Aroclor 1016	2000	U		2000	U		2000	U		2000	U		2000	U		2000	U	
Aroclor 1221	4000	U		4000	U		4000	U		4000	U		4000	U		4000	U	
Aroclor 1232	2000	U		2000	U		2000	U		2000	U		2000	U		2000	U	
Aroclor 1242	2000	U		2000	U		2000	U		2000	U		2000	U		2000	U	
Aroclor 1248	2000	U		2000	U		2000	U		2000	U		2000	U		2000	U	
Aroclor 1254	2000	U		2000	U		2000	U		2000	U		2000	U		2000	U	
Aroclor 1260	2000	U		2000	U		2000	U		2000	U		2000	U		2000	U	

Results are reported on a ug/kg Dry-We

EPA REGION 9 - LABORATORY - RICHMOND, CA
SUMMARY OF ANALYTICAL RESULTS

Case: R02S28
Site: United Heckathorn
SDG: 02199D
Date: 08/14/02
Analysis: Pesticides/PCB
Matrix: Soil, ug/kg dry wt

Sample No.	0702-S17			0702-S18			0702-S19			Method Blank			Method Blank			Method Blank		
Lab Sample ID	AB36134			AB36135			AB36136			PBLK199			PBLK206 Low			PBLK206 High		
Date of Collection	02/06/02			02/06/02			02/06/02			NA			NA			NA		
Analyte	Result	Q	Cmt	Result	Q	Cmt	Result	Q	Cmt	Result	Q	Cmt	Result	Q	Cmt	Result	Q	Cmt
% Solid	74			82			97			NA			NA			NA		
alpha-BHC	800	J	A	100	U		1000	U		10	U		10	U		1000	U	
gamma-BHC	1000	UJ	C	100	U		1000	UJ	C	10	U		10	U		1000	UJ	C
beta-BHC	1000	U		100	U		1000	U		10	U		10	U		1000	U	
delta-BHC	1000	U		100	U		1000	U		10	U		10	U		1000	U	
Heptachlor	1000	U		100	U		1000	U		10	U		10	U		1000	U	
Aldrin	1000	UJ	C	100	U		1000	UJ	C	10	U		10	U		1000	UJ	C
Heptachlor epoxide	1000	U		100	U		1000	U		10	U		10	U		1000	U	
2,4'-DDE	2000	U		200	U		2000	U		20	U		20	U		1000	U	
gamma-Chlordane	1000	U		100	U		1000	U		10	U		10	U		1000	U	
alpha-Chlordane	1000	U		100	U		1000	U		10	U		10	U		1000	U	
4,4'-DDE	2000	U		200			2000			20	U		20	U		2000	U	
Endosulfan I	1000	U		100	U		1000	U		10	U		10	U		1000	U	
2,4'-DDD	1000	J	A	1200			2000	U		20	U		20	U		2000	U	
Dieldrin	1000	U		300			1000	U		20	U		20	U		2000	U	
2,4'-DDT	4000			2600			4000			20	U		20	U		2000	U	
Endrin	2000	U		200	U		2000	U		20	U		20	U		2000	U	
4,4'-DDD	3000			1400			2000	U		20	U		20	U		2000	U	
Endosulfan II	2000	U		200	U		2000	U		20	U		20	U		2000	U	
4,4'-DDT	17000			8000			29000			20	U		20	U		2000	U	
Endrin aldehyde	2000	U		200	U		2000	U		20	U		20	U		2000	U	
Methoxychlor	10000	U		1000	U		10000	U		100	U		100	U		1000	U	
Endosulfan sulfate	2000	U		200	U		2000	U		20	U		20	U		2000	U	
Endrin ketone	2000	U		200	U		2000	U		20	U		20	U		2000	U	
Toxaphene	100000	U		10000	U		100000	U		1000	U		1000	U		100000	U	
Aroclor 1016	20000	U		2000	U		20000	U		200	U		200	U		20000	U	
Aroclor 1221	40000	U		4000	U		40000	U		400	U		400	U		40000	U	
Aroclor 1232	20000	U		2000	U		20000	U		200	U		200	U		20000	U	
Aroclor 1242	20000	U		2000	U		20000	U		200	U		200	U		20000	U	
Aroclor 1248	20000	U		2000	U		20000	U		200	U		200	U		20000	U	
Aroclor 1254	20000	U		2000	U		20000	U		200	U		200	U		20000	U	
Aroclor 1260	20000	U		2000	U		20000	U		200	U		200	U		20000	U	

Results are reported on a ug/kg Dry-We

APPENDIX D

PASSIVE SAMPLER AND WATER CHEMISTRY

WATER QA/QC SUMMARY

PROJECT: Heckathorn Biomonitoring Year 5
PARAMETER: Pesticides, PCBs
LABORATORY: Battelle/Marine Sciences Laboratory, Sequim, Washington
MATRIX: Water, total and dissolved

SAMPLE CUSTODY: **NOTE: This summary applies to bulk water samples collected as part of the annual monitoring program as well as the single outfall water sample for the Phase I Source Investigation, as all water samples were analyzed in the same batch.**

Five water samples (triplicate containers of each) were received on 3/8/02 in multiple coolers. Cooler temperatures ranged from 2.8°C to 6.2°C. All containers were received in good condition with the exception of sample 303.4 (1780-4): 2 of the 3 bottles for that sample arrived broken. One additional water sample was received in good condition on 3/13/02. The cooler temperature upon arrival was 5.8°C. Samples were assigned a Battelle Central File (CF) identification number (1780) and were entered into Battelle's log-in system.

QA/QC DATA QUALITY OBJECTIVES:

					Detection Limits	
Analyte	**Extraction Method**	**Analytical Method**	**Range of Recovery**	**Relative Precision**	**Target (ng/L)**	**Achieved (ng/L)**
2,4'-DDE	$MeCl_2$	GC-ECD	40-120%	±30%	5	0.15
Dieldrin	$MeCl_2$	GC-ECD	40-120%	±30%	5	0.08
4,4'-DDE	$MeCl_2$	GC-ECD	40-120%	±30%	5	0.09
2,4'-DDD	$MeCl_2$	GC-ECD	40-120%	±30%	5	0.16
4,4'-DDD	$MeCl_2$	GC-ECD	40-120%	±30%	5	0.09
2,4'-DDT	$MeCl_2$	GC-ECD	40-120%	±30%	5	0.07
4,4'-DDT	$MeCl_2$	GC-ECD	40-120%	±30%	5	0.10
PCB Aroclor 1242	$MeCl_2$	GC-ECD	40-120%	±30%	50	43.5
PCB Aroclor 1248	$MeCl_2$	GC-ECD	40-120%	±30%	50	43.5
PCB Aroclor 1254	$MeCl_2$	GC-ECD	40-120%	±30%	50	43.5
PCB Aroclor 1260	$MeCl_2$	GC-ECD	40-120%	±30%	50	43.5

METHOD: On arrival at the laboratory, approximately ½ of each of the water samples (except 1780-11, Outfall) were centrifuged. The supernatant liquid was analyzed as the dissolved fraction. The uncentrifuged water was analyzed as the total fraction.

Water samples for analysis of chlorinated pesticides and PCBs were processed according to Battelle SOP MSL-O-010, *Extraction and Clean-Up of Water for Surrogate Internal Standard Method*. Water samples were extracted with methylene chloride. Interferences were removed by aluminum/silicon column chromatography. Sample extracts were then transferred to cyclohexane and analyzed by capillary-column (DB-1701) gas chromatography with electron-capture detection (GC/ECD) according to SOP MSL-O-016, *Analysis of Polychlorinated Biphenyls and Chlorinated Pesticides by Gas Chromatography with Electron Capture Detection*, following EPA Method 8080A quality control criteria (EPA 1986).

WATER QA/QC SUMMARY

HOLDING TIMES: All extractions and analyses were conducted within target holding times: 14 days to extraction, and 40 days to analysis after extraction. Samples were collected on 3/5/02, received on 3/8/02, and held at 4°C. Samples were extracted from 3/8/02 to 3/18/02 and analyzed from 3/21/00 to 3/27/02. The sample that arrived separately on 3/13/02 was extracted on 3/18/02 and analyzed in the same batch as the initial samples.

DETECTION LIMITS: Detection limits were determined by a previously conducted MDL study where replicates were analyzed and the standard deviation was multiplied by the Student's-t value for the number of replicates. Sample detection limits are calculated using the achieved detection limit and the sample volume.

METHOD BLANKS: One method blank was analyzed with the set of samples. None of the analytes of interest were detected in Blank 1; 4,4'-DDE was detected in Blank 2 (associated with dissolved samples) at a concentration less than 5 times its MDL. Dissolved samples with 4,4'-DDE detected at concentrations less than 5 times their blank values were flagged with a "B".

BLANK SPIKES: Two pairs of blank samples (reagents only, carried through all sample preparation processes) were spiked with 33.3 ng/L Dieldrin and 4,4'-DDT, and 333 ng/L Aroclor 1254. Blank spike recoveries of the three spiked analytes of interest ranged from 65% to 105%, and were within the target range of 40%-120%.

MATRIX SPIKES AND MATRIX SPIKE DUPLICATES: Two pairs of matrix spike samples (MS A and MS B) were prepared and analyzed using additional portions of sample 303.2. Three analytes of interest, dieldrin, 4,4'-DDT, and Aroclor 1254, were spiked into the samples at concentrations of 13.9 ng/L dieldrin and 4,4'-DDT, and 139 ng/L Aroclor 1254 in the first MS A/MS B pair, and 18.9 ng/L dieldrin and 4,4'-DDT, and 189 ng/L Aroclor 1254 in the second MS A/ MS B pair. Matrix spike recoveries ranged from 66% to 115%, and were within the target range of 40%-120%.

Replicate precision of the MS A/MS B analyses, expressed as the RPD between the MS A and MS B pairs, was within the QC criteria of ±30% for dieldrin (0% and 12%); 4,4'-DDT (2% in both pairs); and Aroclor 1254 (1% in both pairs).

REPLICATES: Two portions of sample 1780-2 (303.2) were analyzed in duplicate for the analytes of interest. Precision of duplicate analysis is determined by calculating the relative percent difference (RPD) of replicate results. In the first pair of duplicates, RPDs of all detected analytes of interest ranged from 13% to 25%, and were all within the QC limits of ±30%. In the second pair of duplicates, RPDs of all detected analytes of interest ranged from 32% to 54%, exceeding the QC limits of ±30%; however, the concentrations of these analytes in the sample were less than 10 times their respective MDLs.

SURROGATE RECOVERIES: Chlorinated compounds PCBs 103 and 198 were added to each sample during the preparation step as surrogates to assess the efficiency of the extraction procedure. Recoveries of surrogate PCB 198 exceeded the target range of 40%-120% in three samples: 138% in 1780-1b (300.1); 139% in 1780-11 (Outfall); and 132% in Blank 2 Spike B. The data were flagged and no other corrective action was taken. Surrogate recoveries among all other analyses ranged from 40.2% to 118% and were within the target range.

BATTELLE MARINE SCIENCES LABORATORY
1529 West Sequim Bay Road
Sequim, WA 98382-9099
360/681-3687

LOCATION:	
MSL Code	1780-11
STATION NO	Concrete Pipe Outfall
Matrix	Seawater
Extraction Date	03/18/2002
Dilution	10x
Analytical Batch	1
Unit	ng/L
2,4'-DDE	12.4 D
Dieldrin	2520 D
4,4'-DDE	238 D
2,4'-DDD	1240 D
4,4'-DDD	546 D
2,4'-DDT	959 D
4,4'-DDT	1460 D
AROCLORS	
1242	183 U
1248	183 U
1254	183 U
1260	183 U
SURROGATE RECOVERIES (%)	
PCB103	NQ
PCB198	139 #

U Not detected at or above DL shown
D Sample extract diluted 10x.
Outside QAQC limits (SIS 40-120%R; RPD ≤30%D)

PASSIVE SAMPLER QA/QC SUMMARY

PROJECT: Heckathorn Biomonitoring Year 5
PARAMETER: Pesticides, PCBs
LABORATORY: Battelle/Marine Sciences Laboratory, Sequim, Washington
MATRIX: Passive Water Samplers (Semi-permeable membrane devices [SPMD])

SAMPLE CUSTODY: Eight SPMD samples were received in two deliveries on 3/8/02 and 3/19/02. All samples were received in good condition. The cooler temperature on arrival of the first shipment was 5.8°C; the second shipment was 2°C. SPMD samples were then assigned a Battelle Central File (CF) identification number (1782) and were entered into Battelle's log-in system, then frozen until analysis.

QA/QC DATA QUALITY OBJECTIVES:

Analyte	Extraction Method	Analytical Method	Range of Recovery	Relative Precision	Detection Limits: Target (ng/g wet)	Detection Limits: Achieved (ng/g wet)
2,4'-DDE	$MeCl_2$	GC-ECD	40-120%	±30%	2	1.82
Dieldrin	$MeCl_2$	GC-ECD	40-120%	±30%	2	1.82
4,4'-DDE	$MeCl_2$	GC-ECD	40-120%	±30%	2	1.82
2,4'-DDD	$MeCl_2$	GC-ECD	40-120%	±30%	2	1.82
4,4'-DDD	$MeCl_2$	GC-ECD	40-120%	±30%	2	1.82
2,4'-DDT	$MeCl_2$	GC-ECD	40-120%	±30%	2	1.82
4,4'-DDT	$MeCl_2$	GC-ECD	40-120%	±30%	2	1.82
PCB Aroclor 1242	$MeCl_2$	GC-ECD	40-120%	±30%	20	ND
PCB Aroclor 1248	$MeCl_2$	GC-ECD	40-120%	±30%	20	ND
PCB Aroclor 1254	$MeCl_2$	GC-ECD	40-120%	±30%	20	36.4
PCB Aroclor 1260	$MeCl_2$	GC-ECD	40-120%	±30%	20	ND

ND Only Aroclor 1254 was detected.

METHOD: SPMD samples for analysis of PCBs as Aroclors were processed according to Battelle SOP MSL-O-009, *Extraction and Clean-Up of Sediments and Tissues for Semivolatile Organics Following the Surrogate Internal Standard Method*, which is derived from NOAA NS&T and EPA methods with modifications from Krahn et al. (1988). Approximately 0.5 g of SPMD sample material was combined with hexane and sealed in a glass jar with a Teflon-lined lid for 2 days. Interferences in the extract were removed using an alumina/silica column chromatography step. Sample extracts were then transferred to cyclohexane and analyzed by capillary-column (DB-1701) gas chromatography with electron-capture detection (GC/ECD) according to SOP MSL-O-016, *Analysis of Polychlorinated Biphenyls and Chlorinated Pesticides by Gas Chromatography with Electron Capture Detection*, following EPA Method 8080A quality control criteria (EPA 1986).

The initial analysis of sample 1782-8 (PS-8") showed concentrations of chlorinated compounds too high to quantitate even when diluted 50x and 500x. A smaller mass of SPMD material was reextracted and reanalyzed.

Results of SPMD and poly bag analyses were reported in units of total ng Aroclor.

PASSIVE SAMPLER QA/QC SUMMARY

HOLDING TIMES: Seven of the eight samples were collected on 3/5/02; one additional sample was collected on 3/14/02. Samples were held at 4°C ± 2°C and shipped by overnight courier to the chemistry laboratory. Samples were frozen on receipt at the chemistry laboratory on 3/8/02 and 3/19/02, and held frozen until analysis. Samples were extracted on 4/8/02. GC analysis was conducted from 4/11/02 to 4/14/02 and 4/30/02.

DETECTION LIMITS: Detection limits were determined by a previously conducted MDL study where replicates were analyzed and the standard deviation was multiplied by the Student's-t value for the number of replicates. Achieved detection limits for Aroclor 1254 were higher than target MDL. Where Aroclor 1254 was detected, sample concentrations were clearly higher than the DL; therefore, the achieve MDL has no affect on the data.

Sample-specific detection limits are calculated using the achieved detection limit and the sample weight.

METHOD BLANKS: One method blank was analyzed with the set of samples. All analytes of interest were undetected in the blank.

BLANK SPIKES: With the initial analysis (batch 1), one blank sample (reagents only, carried through all sample preparation processes) was spiked with 91 ng/g Dieldrin and 4,4'-DDT, and 909 ng/g Aroclor 1254. Blank spike recovery of the three spiked analytes of interest ranged from 65% to 108%, and were within the target range of 40%-120%.

A second set of blank spikes was analyzed with the reanalysis of sample 1782-8 (batch 2), spiked at higher analyte levels: 19,200 ng/g Dieldrin and 4,4'-DDT, and 192,000 ng/g Aroclor 1254. Blank spike recoveries of the three spiked analytes of interest ranged from 60% to 98%, and were within the target range of 40%-120%.

REPLICATES: One SPMD sample [1782-1(303.1)] was analyzed in duplicate for the analytes of interest. Precision of duplicate analysis is determined by calculating the relative percent difference (RPD) of replicate results. RPDs of all analytes of interest ranged from 1% to 22%, and were all within the QC limits of ±30%.

Replicate precision of the batch 2 blank spike A and blank spike B analyses, expressed as the RPD between BS A and BS B, ranged from 0% to 26%; all were within the QC limits of ±30%.

SURROGATE RECOVERIES: Chlorinated compounds PCBs 103 and 198 were added to each sample during the preparation step as surrogates to assess the efficiency of the extraction procedure. Surrogate recoveries among all sample analyses were within the target range of 40%-120%, ranging from 58.7% to 107%.

REFERENCES:

Krahn, M.M, CA Wigren, R.W. Pearce, S.K. Moore, R.G. Bogar, W. D. McLeod, Jr., S.L. Chan, and D.W. Brown. 1988. *New HPLC Cleanup and Revised Extraction Procedures for Organic Contaminants.* NOAA Technical Memorandum MNFS F/NWC-153. Standard Analytical Procedures of the NOAA National Facility, 1988. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Seattle, WA.

U.S. EPA. 1986 (Revised 1990). *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846.* 3rd ed. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C.

PASSIVE SAMPLER QA/QC SUMMARY

Deviation Documentation Form
20212-D-002

STUDY NUMBER: NA
Project No. 20212-D-001
Project Manager: Nancy Kohn

Project Title: Heckathorn Monitoring Year 5

Entered by: ES Barrows Date: 6-24-02

The following information is (check one)
[ ] a miscellaneous documentation
[ ] a deviation from Protocol, Work Plan or QA Plan (give title)
[X] a deviation from SOP
(give number and title)

Description:	Mass in grams of SPMDs (Passive Samplers) was not recorded at the time of sample extraction/preparation. Weights of each SPMD were estimated to be between 0.5 and 0.6 g. A value of 0.55 g was used for each sample weight in calculations.
Impact on Project:	No impact on project. Sample mass of 0.55 g was an accurate representation of the sample size; results calculated were within expected ranges.

APPROVED BY:

Project Manager or Study Director Date

File in project notebook or study archive
Send a copy to the MSL QA Officer

PASSIVE SAMPLER EXCEL FILE AND QC (4 PAGES)