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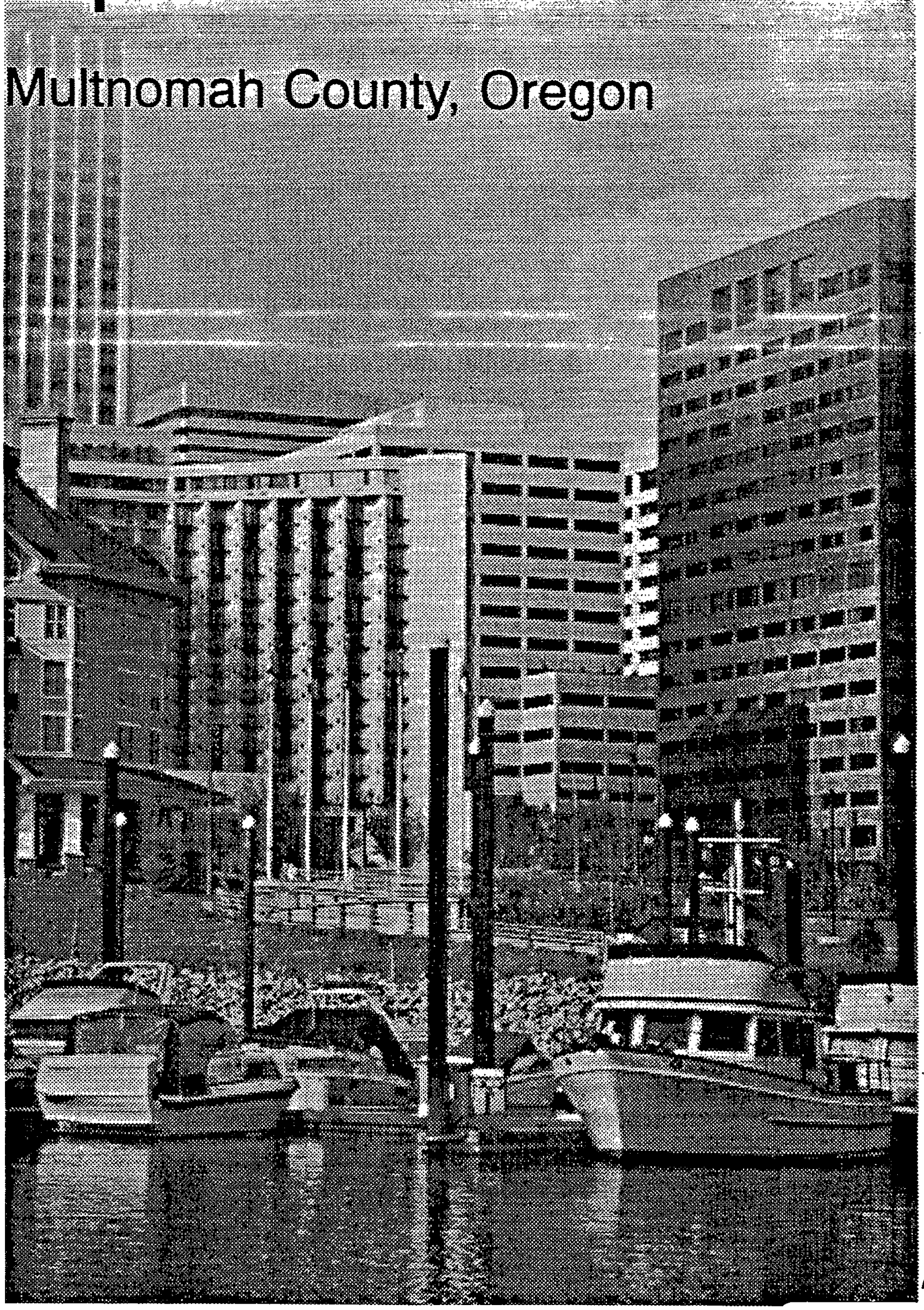
EPA

Portland Harbor Sediment Investigation Report

Multnomah County, Oregon



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PORTLAND HARBOR SEDIMENT INVESTIGATION REPORT
MULTNOMAH COUNTY, OREGON

Prepared for
U.S. Environmental Protection Agency
Region X
1200 Sixth Avenue
Seattle, Washington 98101

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May 1998

Prepared by
Roy F. Weston, Inc.
700 Fifth Avenue
Suite 5700
Seattle, WA 98104-5057

ARCS QUALITY ASSURANCE CONCURRENCE

Project Name:	Portland Harbor Sediment Investigation Multnomah County, Oregon
Contract Number:	68-W9-0046
Work Assignment Number:	46-23-0JZZ
Responsible Organization:	Roy F. Weston, Inc. 700 Fifth Avenue, Suite 5700 Seattle, Washington 98104

Concurrences:

Name: Karen M. Stash
Title: Project Manager, Roy F. Weston, Inc.

Signature: [signature] Date 5/15/98

Name: Steve R. Fuller, RG
Title: Manager, Roy F. Weston, Inc.

Signature: [signature] Date: 5/21/98

Name: Frank C. Monahan, PE
Title: ARCS Program Manager, Roy F. Weston, Inc.

Signature: [signature] Date 5/21/98

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SECTION 1

INTRODUCTION

Pursuant to United States Environmental Protection Agency (EPA) Contract No. 68-W9-0046, Multiple Site Inspections, and Work Plan Addendum (WPA; WESTON 1997c) to the Work Plan: Site Inspections—Multiple Sites (WESTON, 1993), Roy F. Weston, Inc. (WESTON®) conducted a Site Inspection (SI) of a six-mile reach of the Willamette River in Portland, Oregon (see Figure 1-1).

The EPA SI process is intended to evaluate actual or potential environmental hazards at a particular site relative to other sites across the nation for purposes of identifying remedial action priorities. The SI, under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and the Superfund Amendments and Reauthorization Act of 1986 (SARA), is intended to collect sufficient data to enable evaluation of the site's potential for inclusion on the National Priorities List (NPL) and, for those sites determined to be NPL candidates, establish priorities for additional action. The decision as to whether the site is placed on the NPL list is made based on the EPA's revised Hazard Ranking System (HRS) criteria. The HRS assesses the relative threat to human health and the environment associated with the actual or potential releases of hazardous substances at a site.

In addition, this SI was performed at the request of the Oregon Department of Environmental Quality (ODEQ) in an effort to aid their site assessment program.

This document presents a summary of the objectives, sampling activities, and results of the Willamette River SI. Included are site background information (Section 2), project description (Section 3), sampling and analytical results (Section 4), and references.

SECTION 2

BACKGROUND

2.1 SITE LOCATION AND DESCRIPTION

The Willamette River originates in the Cascade Mountain Range and flows approximately 187 miles north before discharging into the Columbia River. From this location, the Columbia River flows an additional 100 miles westward to the Pacific Ocean. The point of confluence of the Willamette and Columbia rivers denotes river mile 0 (RM 0). Most development along the Willamette River has occurred within the project area, referred to as the Portland Harbor. Portland Harbor has been dredged to provide a shipping channel generally 300 feet wide and 40 feet deep from the mouth of the Willamette River upriver to the Broadway Bridge (RM 11.8) (Caldwell and Doyle 1995). Channel depths currently range from 10 to 140 feet, with an average depth of 45 feet. In this reach, the river is deep, slow moving, and tidally influenced. During periods of medium and low flows, tidal effects are evident to RM 26.5 (Willamette Falls); reverse flow has been measured as far upstream as Ross Island (RM 15) during low flow periods.

Habitat in the Willamette River near Portland has been altered to accommodate urban development and a growing shipping industry. Shoreline features include steeply sloped banks covered with riprap or constructed bulkheads, with manmade structures such as piers and wharves extending out over the water. Because of dredging, many portions of the riverbed are steeply sloped and maintain substrates composed mainly of silts and sands (Farr and Ward 1991).

2.2 INDUSTRIAL OPERATIONS IN THE PROJECT AREA

Much of the upland areas adjacent to the Willamette River within Portland Harbor is heavily industrialized, and marine traffic within the river is considered to be intensive. Within the 6-mile project area, a number of industrial operations have been identified as potential sources of contamination to sediment in the Willamette River. Historical or current industrial operations include hazardous waste storage; marine construction; bulk petroleum product storage and handling; oil fire fighting training activities; oil gasification plant operations; wood-treating; agricultural chemical production; battery processing; liquid natural gas plant operations; chlorine production; ship loading and unloading; ship maintenance and repair (i.e., sandblasting, scaling, repair, painting, refueling); and rail car manufacturing.

2.3 INVESTIGATIVE AND REGULATORY HISTORY

Numerous past investigations within the Portland Harbor area have been conducted at varying levels of scope. A portion of the studies focused on specific properties, while the remaining studies were river-wide and incorporated sediment sampling as one component of the entire study. A summary of existing sediment chemical data is provided in the Executive Summary of Historical Sediment Data (WESTON 1997a). Past sediment studies have demonstrated the presence of polycyclic aromatic hydrocarbons (PAHs), pesticides, polychlorinatedbiphenyls (PCBs), dioxins, total inorganics, organotins, pentachlorophenol, and solvents in sediment. These contaminants may have entered the river via spillage during product shipping and handling, direct disposal or discharge, accidental spills, contaminated groundwater discharge, surface water runoff, stormwater discharge, or contaminated soil erosion. Of particular note, a recent sediment investigation conducted by the U.S. Army Corps of Engineers (COE 1998), which includes portions of the Willamette River within our study area, was released subsequent to the implementation of this study. Please refer to this document for further background information regarding sediment conditions associated with the Willamette River.

2.4 REGIONAL GEOLOGY

The following discussion of the regional geologic setting is summarized from several published reports on the geology of the area: Beeson et al. 1991, Madin 1990, Tolan and Beeson 1984, Allen 1975, and Waitt 1985.

The geology of the Portland area is characterized generally by a broad structural depression or basin bordered by the Cascade mountains on the east and the Coast Range mountains on the west. Geologic formations in the basin are also folded and dissected by a number of northwest-trending faults. The Tualatin mountains form a northwest-trending anticlinal ridge that is faulted along its eastern flank by the Portland Hills fault. The Willamette River flows along the base of the eastern side of the Tualatin Mountains. A number of additional faults are located approximately parallel or perpendicular to the Portland Hills fault and are mapped along or near the Tualatin mountains. An inferred graben is identified immediately southeast of the site (Beeson et al. 1991).

A description of the geologic formations of regional significance that may be present at or near the site is presented below (from oldest to youngest):

- **Columbia River Basalt Group**—The Portland basin is underlain by the Columbia River Basalt Group, which consists of flood basalt that erupted 17 to 6 million years ago. These Miocene-age flood basalts are characterized by a thick sequence of dense basalt flows that are separated by permeable interflow zones. These interflow zones are generally highly productive aquifers. This unit has been folded and faulted and forms the Tualatin Mountain uplands southwest of the site. The Columbia River Basalt Group dips steeply to the northeast near this area and is estimated to extend to a depth of 300 to 450 feet below (Madin 1990), with a thickness of more than 650 feet. Fluvial sediments of the Sandy River Mudstone and the Troutdale Formation overlie the Columbia River basalt flows.

- **Sandy River Mudstone**—These deposits of Miocene to Pliocene age are friable to moderately indurated siltstone, sandstone, and claystone derived from an ancestral Columbia River that flowed into the Portland basin from the east. The deposits are found at thicknesses of up to 900 feet near Troutdale. However, outcrops of Sandy River Mudstone are not found near the Tualatin Mountains; the unit may pinch out or may have been scoured out in this part of the basin. The Sandy River Mudstone is overlain by the Troutdale Formation.

- **Troutdale Formation**—The Troutdale Formation is of Miocene to Pliocene age and, in this area, consists of interbedded conglomerates and finer-grained deposits (Beeson et al. 1991). The Troutdale Formation is characterized by pebbly to cobbly conglomerates consisting primarily of Columbia River basalt clasts with foreign clasts of volcanic, platonic, and metamorphic rocks, and interbeds of micaceous arkosic and vitric sandstone (Tolan and Beeson 1984; Beeson et al. 1991). East of the Willamette River, outcrops of the Troutdale Formation are composed of locally derived pebbly to cobbly vitric sandstone with basalt clasts from Boring and Cascade lavas (Tolan and Beeson 1984). Major regional aquifers are established in the Troutdale Formation in much of the east Portland area. The thickness of the Troutdale Formation ranges from 900 feet near Troutdale to 200 to 300 feet in the western parts of the basin near the Tualatin Mountains (Beeson et al. 1991).

- **Boring Formation**—During Pliocene-Pleistocene time, volcanic lavas were erupted from approximately 90 vents throughout the Portland and Vancouver area. Where present, these volcanic deposits overlie the Troutdale Formation (Allen 1975). Boring lava thicknesses are greatest near source vents; however, thicknesses rapidly decrease and pinch out away from source vent areas.

- **Catastrophic Flood Deposits**—During the Pleistocene time, thick deposits of boulders, gravels, sands, and silts accumulated throughout the Portland basin, as a result of the repeated failures of glacial ice dams that impounded glacial Lake Missoula (Waitt 1985). These catastrophic flood deposits form the terrace surfaces in the eastern Portland area and are composed of three different facies. Coarse-grained pebble to boulder gravels and sand make up the core of these terraces, with fine-grained sand and silt deposits mantling the coarser-grained facies. A finer-grained, interlayers silt, sand, and gravel facies is found adjacent to the Columbia and Willamette River channels. The coarse-grained facies reach maximum thicknesses of 100 to 130 feet. The channel facies typically range in thickness from 15 to 45 feet (Beeson et al. 1991).

- **Recent Alluvium**—Recent alluvium consists of Quaternary deposits or river sands, silts, and gravels deposited by the Willamette and Columbia rivers. These deposits are generally limited to the channel bottoms and floodplains of these rivers, and reach maximum thicknesses of about 150 feet (Beeson et al. 1991).

In addition to these geologic formations, imported sand fill is common along many of the floodplain terraces adjacent to the Willamette and Columbia rivers. The source of this fill is primarily dredged material from the shipping channels in these two waterways.

2.5 AQUATIC RESOURCES AND CRITICAL HABITATS

Recent studies have identified 39 species of fish in the Willamette River within the project area. The lower Willamette River upstream to the Willamette Falls provides a significant migratory corridor, nursery habitat, and adult forage area for two runs ofchinook, two runs of steelhead, and individual runs of coho and sockeye salmon (Melcher 1998; Farr and Ward 1991). In general, chinook and steelhead populations are the largest and most widespread of the salmonids found in the Willamette River basin (Melcher 1998). Pursuant to 50 CFR 17.11 & 17.12, steelhead salmon utilizing the Willamette River within the study area are currently classified as threatened per the Endangered Species Act of 1973. A threatened species is qualified as a species that is likely to become endangered within the foreseeable future. Pacific lamprey are also present in the river and are currently classified as a species of special concern by the U.S. Fish and Wildlife Service (USF&WS). The USF&WS defines species of special concern as those organisms whose conservation status is of concern to the USF&WS, but for which further information is needed. Pacific Lamprey are also classified by the Oregon Fish and Wildlife Commission as a sensitive specifies (OAR 635-100-040). The state of Oregon defines sensitive species as naturally reproducing native vertebrates that are likely to become threatened or endangered throughout all or a significant portion of their range in Oregon. The Sensitive Species List is for the express purpose of encouraging actions that will prevent further decline in species' populations and/or habitats and thus avoid the need for listing.

Commercial fishing in the Willamette River within the project area is limited to a small Pacific lamprey fishery (Melcher 1998). In contrast, recreational fishing is extremely popular throughout the lower Willamette basin. Resident species such as largemouth bass, black crappie, white crappie, and walleye support a significant year-round recreational fishery. Significant angling pressure is also directed toward spring chinook, steelhead, coho, American shad, and white sturgeon (Melcher 1998; Farr and Ward 1991).

Numerous piscivorous birds, migratory waterfowl, and raptors utilize the lower Willamette River during various times of the year. Great blue heron, cormorant, osprey, merganser, kingfisher, and bald eagle routinely forage within the study area. Both great blue heron and osprey nest sites are located in the vicinity of the study area and represent significant potential receptors.

2.6 POTENTIAL CONTAMINANT TRANSPORT PATHWAYS AND RECEPTORS

2.6.1 Sediment

Sediment located in areas of direct deposition of waste materials or receiving contaminated surface water drainages may act as a receptor, and, in turn, also act as a source, because the sediment can retain contaminants. In addition, sediment can be transported by currents and wave action and as a result can function as a source of contamination at locations distal from the original source materials.

Within the 6-mile study area, the sediments represent a receptor as well as a source, as some of the types of contaminants present in the historically collected sediment samples (e.g., PAHs, total inorganics, pesticides, PCBs, etc.) tend to strongly sorb to particulate matter, may accumulate over time, and may be re-released to the water column via disturbance or dissolution during transport. The hydraulic characteristics of the area further suggest that transport of contaminated sediments to areas up- and downriver, may occur. Aquatic organisms represent additional receptors that may be impacted by sediment-bound contaminants due to exposure via dermal contact, respiration, or direct ingestion. Exposed lower trophic-order organisms also provide a pathway for exposure of higher trophic-order organisms via ingestion of contaminated prey.

The potential for sediments to act as a receptor and a source at locations both adjacent to and distal from the site was evaluated through the collection and chemical analysis of surface and subsurface sediment and sediment porewater from areas within the 6-mile study area (see Section 3.2).

2.6.2 Surface Water

Surface water runoff associated with upland areas adjacent to the Willamette River is dependent upon climatic influences and varies according to season. No sources of drinking water are derived from surface water associated with the 6-mile study area. The primary ecological receptors include anadromous and resident populations of fish occurring in the Willamette River. Secondary ecological receptors include numerous piscivorous birds, migratory waterfowl, and raptors, which utilize the lower Willamette River during various times of the year.

Potential groundwater pathways leading to downgradient surface water are another potential pathway, and were addressed through the sediment pathways.

2.6.3 Soil

Although this media may represent a source of contamination or an exposure mechanism to terrestrial receptors, soil conditions associated with adjacent upland areas were not evaluated as part of this investigation. However, soil that may have been transported to nearshore sediment was evaluated as part of the sediment pathway.

2.6.4 Groundwater

The groundwater pathway was not directly evaluated for this site, but the sediment pathway may capture areas of significant groundwater contamination that has impacted sediment quality.

2.6.5 Air

Particulate migration from the upland properties to the Willamette River was considered a potential pathway of contaminant transport and was evaluated as part of the sediment pathway investigation described above.

SECTION 3

PROJECT DESCRIPTION

3.1 SAMPLING OBJECTIVES

The EPA process is intended to evaluate actual or potential environmental hazards at a particular site relative to other sites across the nation for purposes of identifying remedial action priorities. This SI was intended to collect sufficient data to support a HRS evaluation for a 6-mile section of the Willamette River. The data collection efforts in this project area are also intended to support ODEQ's ongoing investigations for potential remedial actions associated with possible upland sources adjacent to the Willamette River.

The purpose of this investigation is to provide a screening level evaluation of sediment contamination in the Portland Harbor reach of the Willamette River. Accordingly, the following sampling objectives were defined for this investigation:

- Characterize the nature and magnitude of contamination in surface and shallow subsurface sediments
- Obtain sediment porewater samples to evaluate the potential bioavailability of organotins and total inorganics to aquatic receptors.

Based on historical data (WESTON 1997a), contaminants of potential concern in sediment include total inorganics, base-neutral acid extractables (BNAs) (primarily PAHs), PCBs, pesticides, and organotins. Because organotins were of potential concern, this investigation also focused on evaluating the potential bioavailability of organotins to aquatic receptors through the collection and analysis of sediment porewater.

3.2 SAMPLE TYPES, NUMBERS, LOCATIONS, AND RATIONALE

In total, 227 samples were collected during the SI field effort, as follows:

- 150 surface (0 to 10 cm) sediment samples, plus 8 field duplicates.
- 28 sediment porewater samples, plus 2 field duplicates.
- 37 subsurface (1.8 to 4.55 feet) sediment samples (sediment cores), plus 2 field duplicates.

Surface and subsurface sediment sampling locations are depicted in Figures 3-1 through 3-5. Porewater stations and surface sediment stations are provided in Table 3-1.

Split samples were provided to three interested parties owning properties adjacent to the study area. Information detailing interested parties and split sampling locations are provided in Table 3-2.

3.3 SAMPLING METHODS, ANALYTICAL REQUIREMENTS, AND STATION LOCATIONS

3.3.1 Sampling Methods

Surface Sediment Sampling

Subtidal surface sediment samples were collected using a stainless-steel modified 0.1 m^2 van Veen grab sampler, in accordance with the procedures outlined in the sampling and analysis plan (SAP; WESTON 1997b). On average, between 1 and 4 grabs were required at each station, depending on sediment volume requirements associated with bulk chemical and porewater analyses. Penetration depths for acceptable grabs ranged from 6 to 17 cm.

Accepted samples were placed in stainless-steel bowls or soup pots for homogenization. Samples submitted for bulk chemical analysis were placed in labeled pre-cleaned sample jars, while samples submitted for porewater analysis were placed in decontaminated high-density polyethylene (HDPE) buckets. All sample containers were subsequently packed in coolers with ice for shipment. Observations of sediment composition were made for each sample and recorded on the appropriate field sample record forms (see Appendix A.1).

Subsurface Sediment Sampling

In accordance with the SAP (WESTON 1997b), all subsurface sediment sampling was conducted using a 3-inch-diameter gravity corer, configured with a 5-foot core barrel and a 700-pound weight stand. Core recovery lengths varied throughout the study area. Core recovery ranged from 1.8 to 4.55 feet, and averaged 3.2 feet. A summary of the recovery lengths is provided in Table 3-3. On average, between three to six casts of the gravity corer were required to acquire an acceptable core. A minor deviation from the SAP entailed the rate of descent of the gravity corer. Due to hard substrates encountered immediately below the mudline, the rate of descent increased from the proposed 1 foot/second to approximately 6 feet/second (free fall) to maximize the impact of the corer and increased core penetration. Core collection observations were recorded on appropriate field record forms (see Appendix A.2).

Core processing was conducted at an onshore location. Sediment from each core was extruded onto a decontaminated 5-foot stainless-steel tray by elevating the tube at an angle. When necessary, the core was tapped with a rubber mallet to loosen the sediment from the liner. Care was taken to ensure that samples were extruded as slowly as possible to maintain the cylindrical form of the core. Once the core sediment was extruded onto the tray, observations of sediment composition were made and recorded on the appropriate field sample record forms (see Appendix A.3). Samples were placed in stainless-steel bowls for homogenization. Samples submitted for bulk chemical analysis were placed in labeled pre-cleaned sample jars. All sample containers were subsequently packed in coolers with ice for shipment.

Latitude and longitude data are provided in Appendix A.4.

3.3.2 Analytical Requirements

In general, all samples were analyzed in accordance with the methods and procedures specified in the SAP (WESTON 1997a). A few minor deviations from the proposed sample analytical requirements occurred, as follows:

- A chlorinated herbicide analysis was not originally proposed for surface sediment sampling location WR-SD-SD092-0000; however, during the field sampling effort, a strong pesticide odor was detected at this location. Based on these observations and in consultation with EPA, chlorinated herbicide analysis was subsequently added to the analytical requirements for this location.

- Organotin (i.e., tributyltin) analysis was originally proposed at surface sediment sampling location WR-SD-SD064-0000; however, during the field sampling effort, this station was inadvertently omitted from the laboratory analysis request form. As a result, no organotin sediment data are available for this sampling location.

Chemical analyses conducted at each surface sediment sampling location (including those stations evaluating porewater quality) are presented in Table 3-1. Chemical analyses conducted at each subsurface sediment sampling location are presented in Table 3-4.

Duplicate sediment and porewater samples were collected at a frequency of 5 percent or greater per matrix, with eight surface sediment, two subsurface sediment, and two porewater duplicate samples collected for analysis. Temperature blanks were included in all sample coolers shipped to the contracted laboratories.

3.3.3 Station Locations

3.3.3.1 Surface Sediment Stations

Considerable effort was made to collect surface sediment within close proximity of the sampling locations detailed in Figures 3-2 through 3-6 of the SAP (WESTON 1997a). In several instances, sampling locations were moved due to physical obstructions present at the time of sediment collection (e.g., overhead lines, moored vessels, shallow water, etc.). In addition to these factors, substrate material at WR-SD-SD054 was predominantly composed of submerged wood debris, so adequate recovery of surface sediment was not possible at this location. Under this circumstance, multiple attempts were made before this station was abandoned. Sufficient sediment volumes for porewater extraction and analysis could also not be obtained from stations WR-SD-SD051 and WR-SD-SD055 because of insufficient grab sampler penetration due to the presence of hard substrates and abundant wood debris; sediment from these locations were submitted for bulk chemistry only.

3.3.3.2 Subsurface Sediment Stations

Considerable effort was made to co-locate subsurface sediment sampling locations to within 2-meters of the previously occupied surface sediment sampling locations. In several instances, subsurface sediment conditions failed to allow adequate recovery of subsurface sediment. When these conditions were encountered, multiple attempts were made before the coring location was abandoned or moved to an area of more favorable subsurface sediment conditions. All subsurface sediment station-positioning modifications are detailed in Table 3-5.

3.4 SAMPLE HANDLING, PACKAGING, AND SHIPPING

Samples were generally handled, packaged, and shipped in accordance with the procedures specified in the SAP (WESTON 1997b). Minor deviations from the SAP included the following:

- EPA sample tags were not placed on each sample container, as Contract Laboratory Program (CLP) analytical services, which require these tags, were not used.
- Vermiculite was not included in all coolers in which the plastic, 2-gallon buckets containing sediment for porewater extraction were placed, as container breakage was not anticipated to occur due to the container type (plastic) and tight fit of the containers in the coolers.

3.5 DOCUMENTATION

All field documentation, sample designation and labeling, and chain of custody procedures were followed in accordance with the procedures specified in the SAP (WESTON 1997b).

3.6 EQUIPMENT DECONTAMINATION AND INVESTIGATION-DERIVED WASTE

Procedures specified in the SAP (WESTON 1997b) for decontaminating equipment and disposing of investigation-derived wastes (IDW) were followed during field activities.

SECTION 4

SAMPLING RESULTS

The following sections present analytical data generated during this SI. A log summarizing individuals and affiliated agencies contacted during the course of this SI is provided in Appendix B. Chain-of-custody forms and data validation reports can be provided upon request (Appendix C).

4.1 DATA PRESENTATION

Analytical data tables for surface sediment, subsurface sediment, and sediment porewater are presented in Appendix D. Analytical data are reported as follows:

- Sediment inorganics are expressed in units of milligram per kilogram (mg/kg) dry-weight
- Sediment organics are expressed in units of microgram per kilogram (µg/kg) dry-weight; sediment nonionic/nonpolar organics are also expressed in units of µg/kg-organic carbon (i.e., the dry-weight concentration was normalized to the organic carbon content of the sample by dividing the chemical concentration by the sample-specific decimal fraction of organic carbon)
- Sediment porewater inorganics (including organotins) and organics are expressed in units of microgram per liter (µg/L)
- Sediment organotins are expressed in units of µg/kg-dry weight
- Sediment total organic carbon (TOC) and grain size are expressed as percentages

4.2 DATA EVALUATION

4.2.1 Effects-Based Screening Values/Guidelines

No background samples were designated for this investigation. However, numerous effects-based screening values/guidelines are available to assist in the interpretation of potential risks associated with exposures to media associated with this investigation. Several guidelines commonly used in the region include:

4.2.1.1 Sediment Screening Guidelines

- Washington State Sediment Management Standards (SMS) Sediment Quality Standard (SQS) and Cleanup Screening Level (CSL) criteria (WAC 173-204).
- Effects range-low (ER-L) and effects range-median (ER-M) values (Long and Morgan 1990 with 1995 updates).
- Washington State Freshwater Sediment Quality Values (Cubbage et al. 1997).

The SMS include TOC-normalized (i.e., TOCN) criteria for nonionic/nonpolar organic compounds. However, these criteria are generally only effective at predicting adverse effects in sediments with TOC content greater than 0.5 percent (Michelson 1997). Also, in cases where high TOC (greater than 3 to 4 percent) may be due to some anthropogenic contribution (e.g., oils or wood debris), TOC normalization may not be appropriate. To determine the appropriateness of normalizing the organic data for comparisons with these standards, TOC content was reviewed on a sample-by-sample basis and was performed only on those samples with a TOC content between 0.5 and 4 percent. Of note, TOC-normalized data should only be compared to SMS criteria to aid the reader. Both TOC-normalized, where appropriate, and non-normalized data for nonionic/nonpolar organic compounds are provided in Appendix D.

4.2.1.2 Porewater Screening Guidelines

- Federal marine acute and chronic Ambient Water Quality Criteria (AWQC; EPA 1995)
- Oregon State freshwater acute and chronic AWQC (OAR 340-41)
- EPA proposed freshwater acute and chronic AWQC for TBT (EPA 1997)

Summaries of the above screening guidelines, as well as other potentially applicable effects-based screening values, are provided in Appendix E.

4.3 ANALYTICAL RESULTS

4.3.1 Surface Sediment

4.3.1.1 Total Inorganics

Total inorganics (i.e., metals) were analyzed at all surface sediment sampling stations. Analytical results indicated that total inorganics were detected at all stations. Please refer to the table in Appendix D.1-1 for a statistical summary of the data or consult the table in Appendix D.1-2 for a complete listing of the data. Figures 4-1 through 4-7 provide a graphical representation of the inorganic results from this study.

4.3.1.2 Base-Neutral Acid Extractables (BNAs)/Semivolatile Organic Compounds(SVOCs)

BNAs were analyzed at all surface sediment sampling stations and were detected in nearly all surface sediment samples collected in the study. PAHs were most common. High-molecular weight PAHs (HPAHs) were detected in all samples and ranged from 49 to 677,000 µg/kg. The highest HPAH concentration was measured at SD032. Low-molecular weight PAHs (LPAHs) were also widespread and were detected in about 95 percent of the surface sediment stations. LPAHs ranged from 21 to 402,400 µg/kg, with the highest measured concentration occurring at station SD064. A statistical summary of the SVOC data is presented, as dry-weight concentrations, in the table in Appendix D.1-3. A complete data listing of the SVOC data is presented, as dry-weight concentrations, in the table in Appendix D.1-4. The SVOCs data were also normalized to total organic carbon (see Section 4.2.1.1). A statistical summary of the SVOC TOC-normalized data is presented in the table in Appendix D.1-5. A complete data listing of the SVOC TOC-normalized data is presented in the table in Appendix D.1-6. Figures 4-8 and 4-9 provide a graphical representation of HPAH and LPAH results, respectively.

4.3.1.3 Pesticides

Pesticides were analyzed at 39 of the surface sediment sampling stations. Pesticides were infrequently detected with exception to dichloro-diphenyl-trichloroethene (4,4'-DDT) and its associated metabolites (i.e., 4,4'-DDD and 4,4'-DDE). 4,4'-DDT was detected in about 85 percent of those samples analyzed for this analyte and ranged from 1.0 to 3,100 µg/kg. The highest concentrations of pesticides were detected at stations SD092 and SD097. Please refer to the table in Appendix D.1-7 for a statistical summary of pesticide data or consult the table in Appendix D.1-8 for a complete listing of the data. Figure 4-10 provides a graphical representation of DDT results.

4.3.1.4 Polychlorinated Biphenyls (PCBs)

PCBs were analyzed at 45 of the surface sediment sampling stations. The only detected PCB congeners included Aroclor-1254 and Aroclor-1260. Aroclor-1254 was detected in 20 percent of the analyzed samples, while Aroclor-1260 was detected in only one of the 45 samples. Aroclor-1254 ranged from 26 to 580 µg/kg, with the highest concentration measured at station SD133. Please refer to the table in Appendix D.1-7 for a statistical summary of PCB data or consult the table in Appendix D.1-8 for a complete listing of the data. Figure 4-11 provides a graphical representation of total PCB results.

4.3.1.5 Organotins (Reported as Organotin Chloride)

Organotins were analyzed at 61 of the surface sediment sampling stations. The most commonly detected organotin constituent was tributyltin (TBT), occurring in about 90 percent of the samples analyzed for this analyte. TBT ranged from 6.23 to 41,830 µg/kg, with the highest concentration measured at station SD012. Please refer to the table in Appendix D.1-9 for a statistical summary of organotin data or consult the table in Appendix D.1-10 for a complete listing of the data. Figure 4-12 provides a graphical representation of sediment TBT results.

4.3.1.6 Dioxins/Furans

Analyses for dioxins/furans were conducted at three surface sediment sampling locations. Analytical results indicated that dioxins/furans were detected at all three stations. Please refer to the table in Appendix D.1-11 for a statistical summary of these data or consult the table in Appendix D.1-12 for a complete data listing.

4.3.1.7 Chlorinated Herbicides

Analyses for chlorinated herbicides were conducted at seven sampling locations. Detections in herbicides were limited to 2,4-D, 2,4-DB, and pentachlorophenol. The highest detections of all three of these herbicides were at station SD080. Please refer to the table in Appendix D.1-13 for a statistical summary of herbicide data or consult the table in Appendix D.1-14 for a complete data listing. Figure 4-13 provides a graphical representation of 2,4-D results.

4.3.1.8 Total Organic Carbon (TOC)

TOC analysis was performed at all surface sediment sampling stations. Analytical results indicated that TOC averaged about 1.5-percent. Please refer to the table in Appendix D.1-15 for a statistical summary of TOC data or consult the table in Appendix D.1-16 for a complete listing of the data.

4.3.1.9 Grain Size

Grain size analysis was performed at all surface sediment sampling stations. Please refer to the table in Appendix D.1-15 for a statistical summary and to the table in Appendix D.1-16 for a complete listing of the grain size data.

4.3.2 Subsurface Sediment

4.3.2.1 Total Inorganics

Total inorganics were analyzed at all subsurface sediment sampling stations. Analytical results indicated that total inorganics were detected at all stations. Please refer to the table in Appendix D.2-1 for a statistical summary of these data or consult the table in Appendix D.2-2 for a complete listing of the data. Figure 4-1 through 4-7 provide a graphical representation of inorganics results.

4.3.2.2 BNAs/SVOCs

BNAs were analyzed at all subsurface sediment sampling stations and were detected in nearly all analyzed subsurface sediment samples collected in the study. Similar to the surface sediment results, PAH constituents were most common. HPAHs were detected in all but one core and ranged from 135 to 152,700 µg/kg. The highest HPAH concentration was measured at SD035. LPAHs were detected in all cores and ranged from 34 to 69,410 µg/kg, with the highest measured concentration occurring at station SD055. These data indicated that PAHs were, in general, more elevated in surface sediment samples.

A statistical summary of the SVOC data is presented, as dry-weight concentrations, in the table in Appendix D.2-3. A complete data listing of the SVOC data is presented, as dry-weight concentrations, in the table in Appendix D.2-4. The SVOC data were also normalized to total organic carbon. A statistical summary of the SVOC normalized data is presented in the table in Appendix D.2-5. A complete data listing of the SVOC normalized data is presented in the table in Appendix D.2-6. Figures 4-8 and 4-9 provide a graphical representation of HPAH and LPAH results, respectively.

4.3.2.3 Pesticides

Pesticides were analyzed at 20 of the subsurface sediment sampling stations. Pesticides were infrequently detected with exception to 4,4'-DDT and its associated metabolites (i.e., 4,4'-DDD and 4,4'-DDE). 4,4'-DDT was detected in about 65 percent of those samples analyzed for this analyte and ranged from 4.4 to 22,000 µg/kg. 4,4'-DDD was also detected with a high frequency (80-percent) and ranged from 2.2 to 29,000 µg/kg. Highest concentrations of both 4,4'-DDT and 4,4'-DDD were measured at station SD092.

Please refer to the table in Appendix D.2-7 for a statistical summary of pesticide data or consult the table in Appendix D.2-8 for a complete pesticide data listing. Figure 4-10 provides a graphical representation of DDT results.

4.3.2.4 PCBs

PCBs were analyzed at 23 of the subsurface sediment sampling stations. PCB congeners most frequently detected included Aroclor-1254 and Aroclor-1260. Aroclor-1254 was detected in about 61 percent of the analyzed samples, while Aroclor-1260 was detected in about 39 percent of the samples. Aroclor-1242 was detected in one sample. Aroclor-1254 ranged from 15 to 1,500 µg/kg, while Aroclor-1260 ranged from 24 to 810 µg/kg. Highest PCB concentrations were measured at station SD133. These data indicated that PCBs were, in general, more elevated in subsurface sediment samples.

Please refer to the table in Appendix D.2-7 for a statistical summary of PCB data of subsurface samples or consult the table in Appendix D.2-8 for a complete listing of the data. Figure 4-11 provides a graphical representation of total PCB results.

4.3.2.5 Organotins

Organotins were analyzed at 25 of the subsurface sediment sampling stations. The most commonly detected organotin constituent was TBT, occurring in nearly 70 percent of the samples analyzed for this analyte. TBT ranged from 25 to 13,350 µg/kg, with the highest concentration measured at station SD133. Please refer to the table in Appendix D.2-9 for a statistical summary of organotin data in subsurface sediment or consult the table in Appendix D.2-10 for a complete listing of the data. Figure 4-12 provides a graphical representation of sediment TBT results.

4.3.2.6 Dioxins/Furans

Analyses for dioxins/furans were conducted at three subsurface sediment sampling locations. Analytical results indicated that dioxins/furans were detected at all three stations. Please refer to the table in Appendix D.2-11 for a statistical summary of these data or consult the table in Appendix D.2-12 for a complete data listing.

4.3.2.7 TOC

TOC analysis was performed at all surface sediment sampling stations. Analytical results indicated that TOC averaged about 1.8 percent. Please refer to the table in Appendix D.2-13 for a statistical summary of TOC data or consult the table in Appendix D.2-14 for a complete listing of the data.

4.3.2.8 Grain Size

Grain size analysis was performed at all subsurface sediment sampling stations. Please refer to the table in Appendix D.2-13 for statistical information and the table in Appendix D.2-14 for a complete listing of the grain size data.

4.3.3 Sediment Porewater Analysis

4.3.3.1 Total Inorganics

Total inorganics were analyzed at all 28 sediment porewater sampling stations. Analytical results indicated that total inorganics were detected at all stations. Please refer to the table in Appendix D.3-1 for a statistical summary of these data or consult the table in Appendix D.3-2 for a complete listing of the data.

4.3.3.2 Organotins

Organotins were analyzed at all 28 sediment porewater sampling stations. The most commonly detected organotin constituent included tributyltin (TBT); occurring in 25 percent of the samples analyzed for this analyte. Detected TBT ranged from 0.03 to 0.45 µg/L, with the highest concentration measured at station SD128. Please refer to the table in Appendix D.3-3 for a statistical summary of organotin data in porewater or consult the table in Appendix D.3-4 for a complete listing of the data. Figure 4-14 provides a graphical representation of TBT porewater results.

SECTION 5

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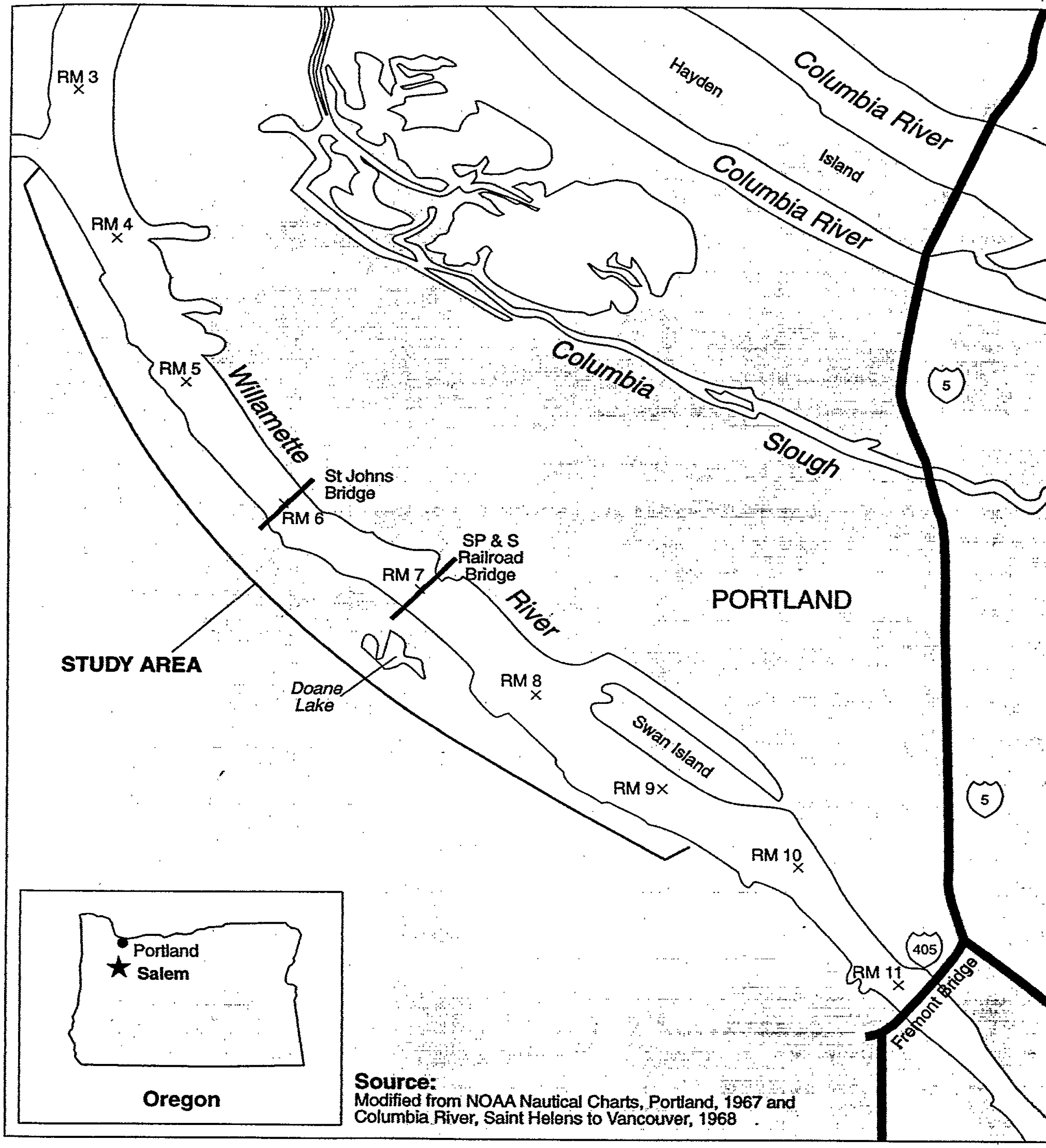
FIGURES



Source:
Modified from NOAA Nautical Charts, Portland, 1967 and Columbia River, Saint Helens to Vancouver, 1968

EXPLANATION

RM 1 × River Mile Marker with Identification

0 1/2 1
Scale in Miles

WESTON
MANAGERS DESIGNERS/CONSULTANTS

98-0232 Fig1-1.fh7

Portland Harbor Sediment Investigation
Portland, OR
Study Area

FIGURE
1-1

Portland Harbor Sediment Investigation Portland, Oregon

Surface and Subsurface Sediment Sampling Locations Between RM 3.5 and RM 5.0

EXPLANATION:

Stations
▲ Surface and subsurface sediments sampling location
Surface sediment sampling location

N

500 0 500 1000 Feet

WESTON

Figure
3-1

98-0067.APR

Map Source: METRO (City of Portland), 1997

Portland Harbor Sediment Investigation Portland, Oregon

Surface and Subsurface Sediment Sampling Locations Between RM 5.0 and RM 6.0

EXPLANATION:

Stations
- ▲ Surface and subsurface sediments sampling location
- Surface sediment sampling location
- -C Indicates core sample could not be co-located with surface sediment sampling location due to subsurface obstruction and/or insufficient recovery.

Note: SD-054 was not collected due to insufficient recovery.

500 0 500 1000 Feet

WESTON

Figure **3-2**

0030

98-0067.APR

Portland Harbor Sediment Investigation Portland, Oregon

Surface and Subsurface Sediment Sampling Locations Between RM 6.0 and RM 7.0

EXPLANATION:

Stations
▲ Surface and subsurface sediments sampling location
Surface sediment sampling location

N

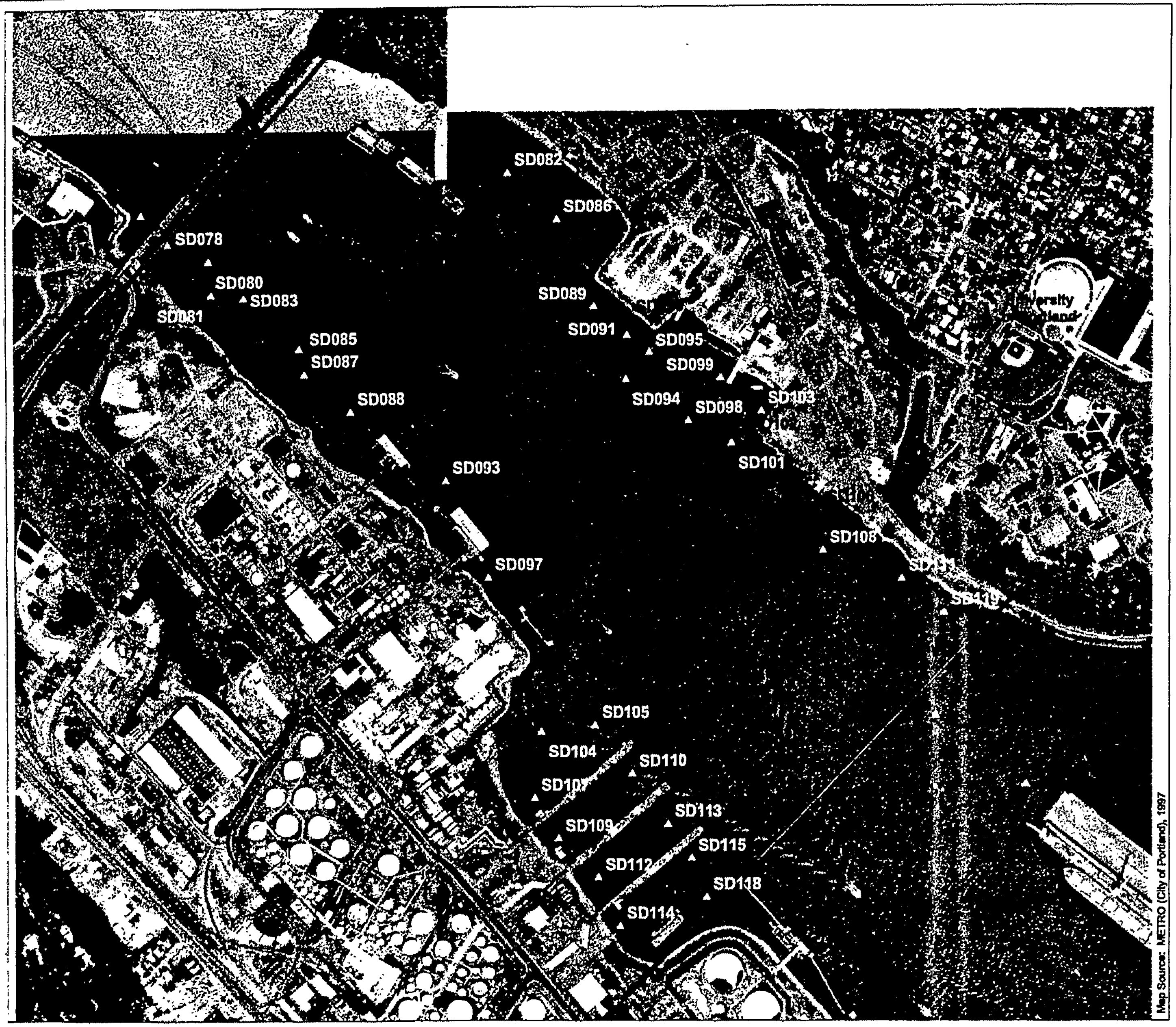
500 0 500 1000 Feet

WESTON

Figure
3-3

0031

98-0067.APR



Portland Harbor Sediment Investigation Portland, Oregon

Surface and Subsurface Sediment Sampling Locations Between RM 7.0 and RM 8.0

EXPLANATION:

Stations

▲ Surface and subsurface sediment sampling location
Surface sediment sampling location

-C Indicates core sample could not be co-located with surface sediment sampling location due to subsurface obstruction and/or insufficient recovery.

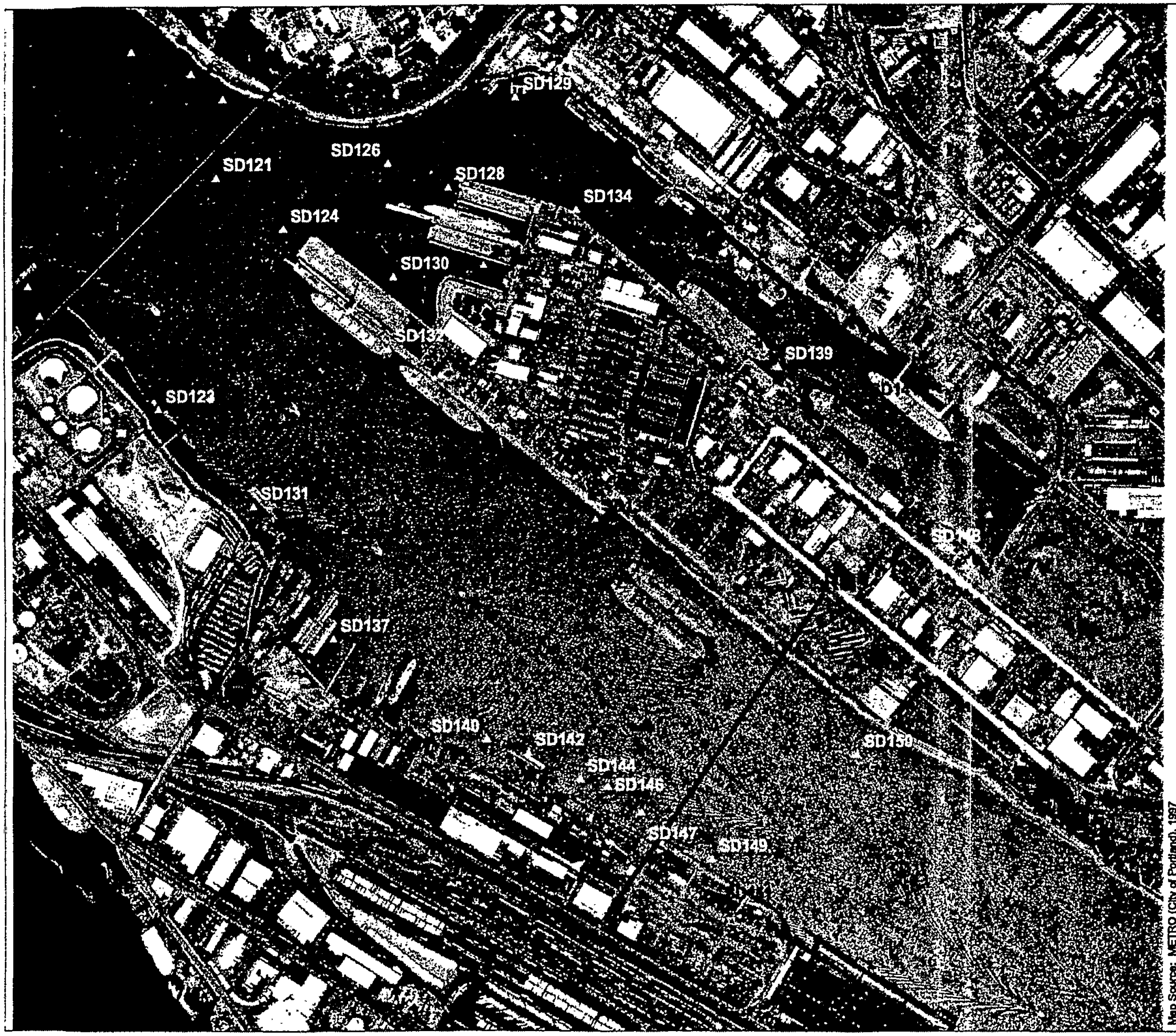
500 0 500 1000 Feet

WESTON

Figure
3-4

98-0067 APR

0032



Portland Harbor Sediment Investigation Portland, Oregon

Surface and Subsurface Sediment Sampling Locations Between RM 8.0 - RM 9.5

EXPLANATION:

Stations

▲ Surface and subsurface sediment sampling location
Surface sediment sampling location

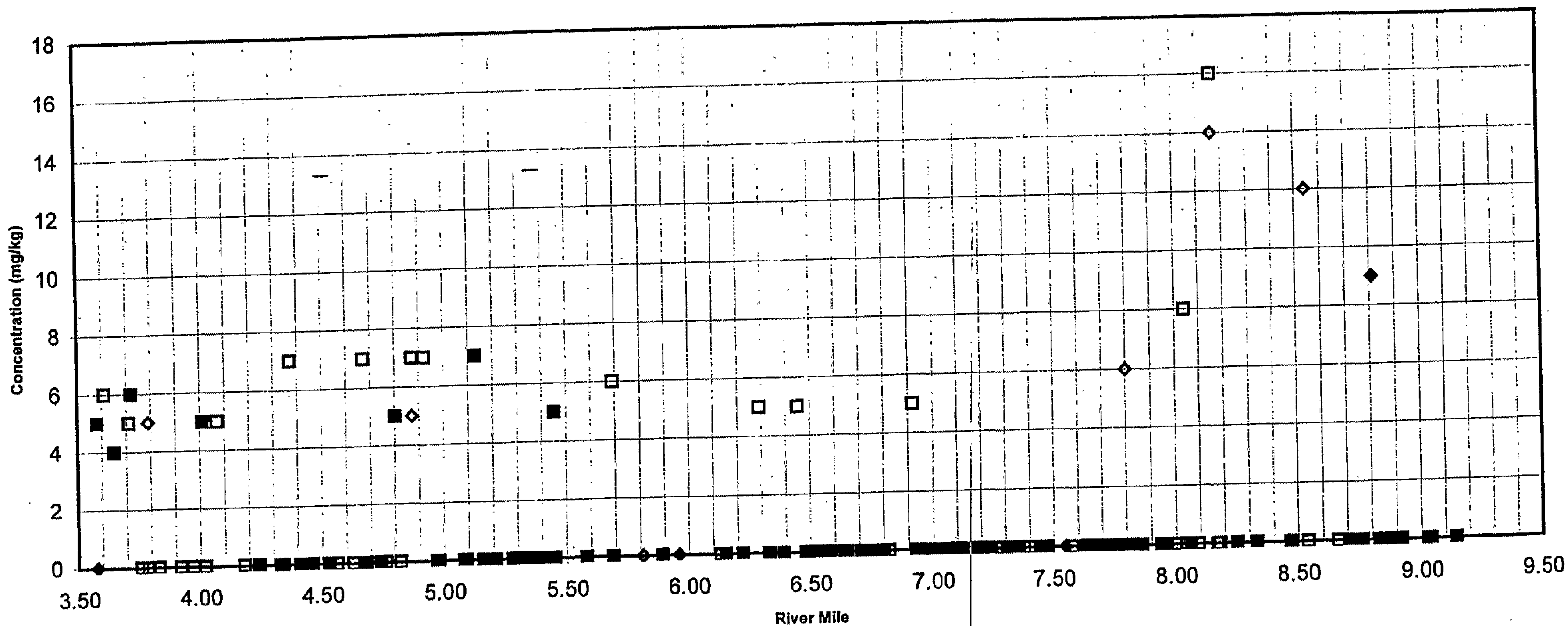
500 0 500 1000 Feet

WESTON

Figure **3-5**

98-0067.APR

0033



Subsurface sediment sample, North Portland side Willamette River
Surface sediment sample, North Portland side of Willamette River
Subsurface sediment sample, Northwest Portland side of Willamette River
Surface sediment sample, Northwest side of Willamette River

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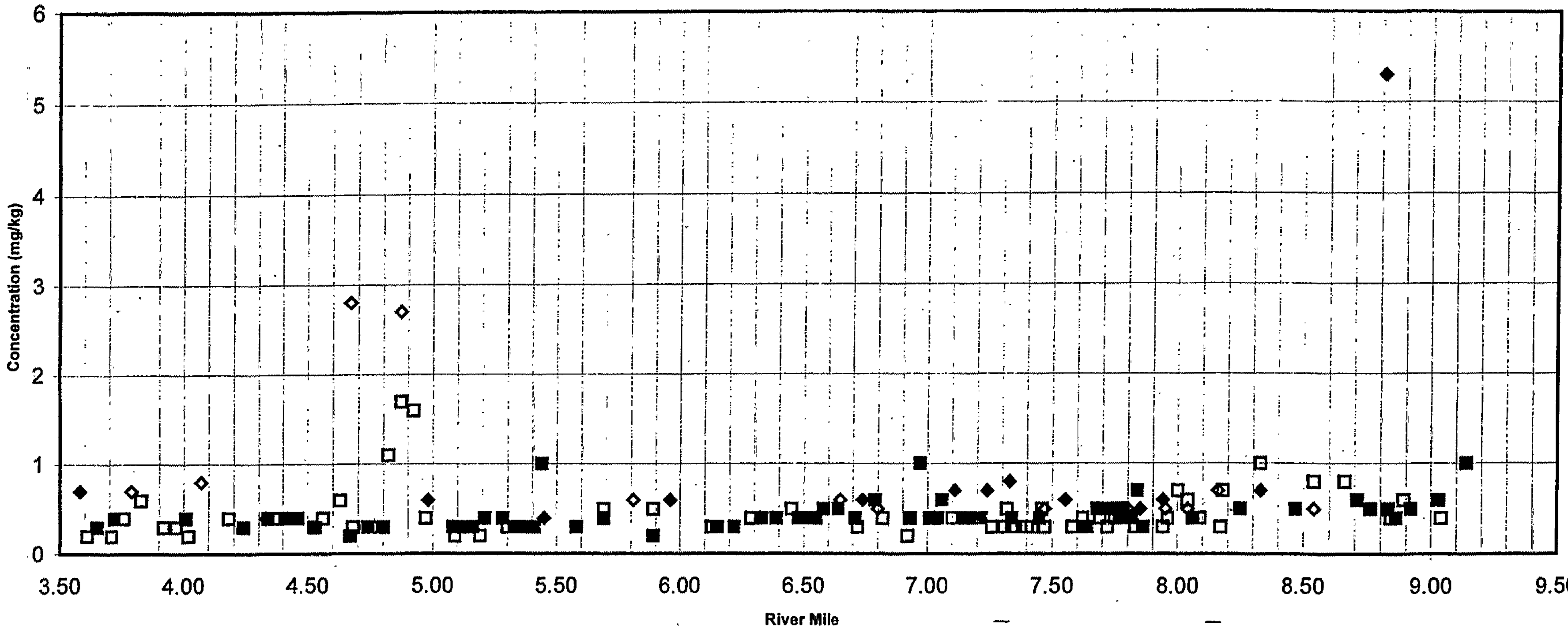
Willamette River
Arsenic Concentrations per River Mile

Figure
4-1

98-0288.frg

0034



- ◇ Subsurface sediment sample, North Portland side Willamette River
- □ Surface sediment sample, North Portland side of Willamette River
- ◆ Subsurface sediment sample, Northwest Portland side of Willamette River
- ■ Surface sediment sample, Northwest side of Willamette River

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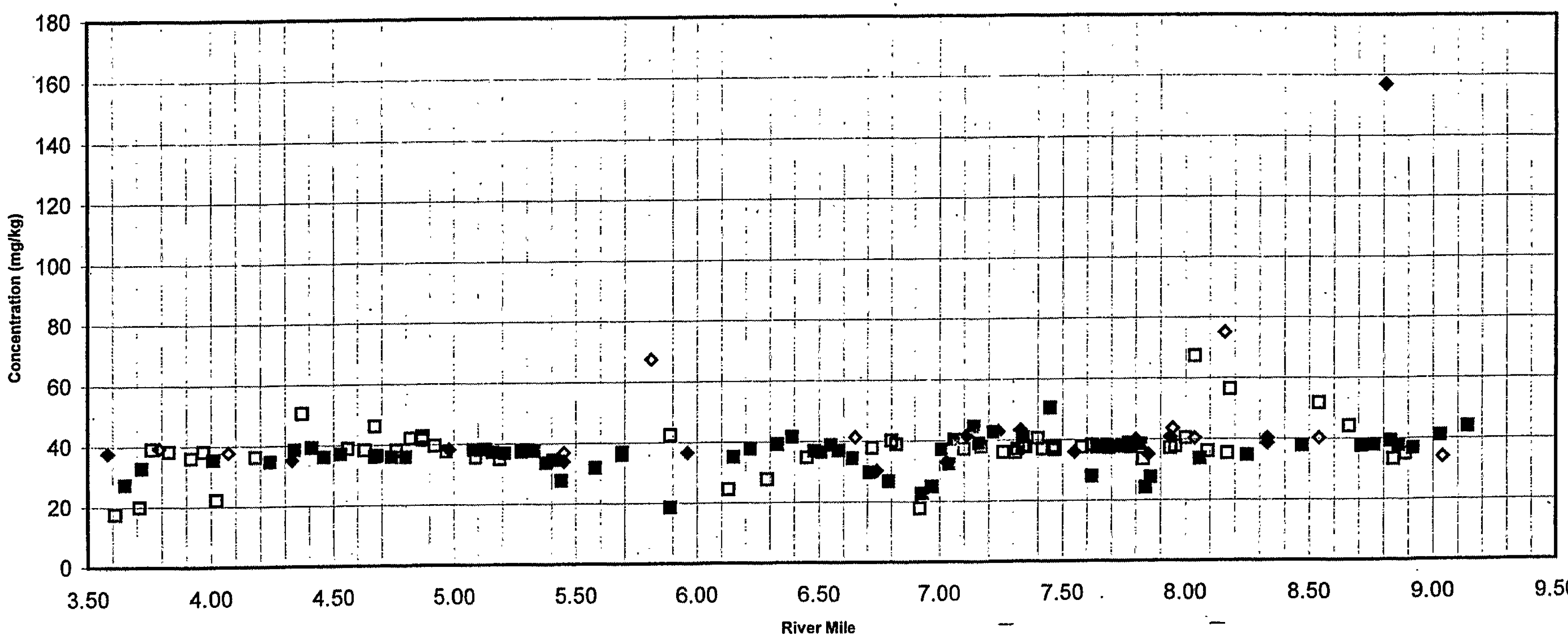
Willamette River
Cadmium Concentrations per River Mile

Figure **4-2**

98-0288.fig



◇ Subsurface sediment sample, North Portland side Willamette River
□ Surface sediment sample, North Portland side of Willamette River
◆ Subsurface sediment sample, Northwest Portland side of Willamette River
■ Surface sediment sample, Northwest side of Willamette River

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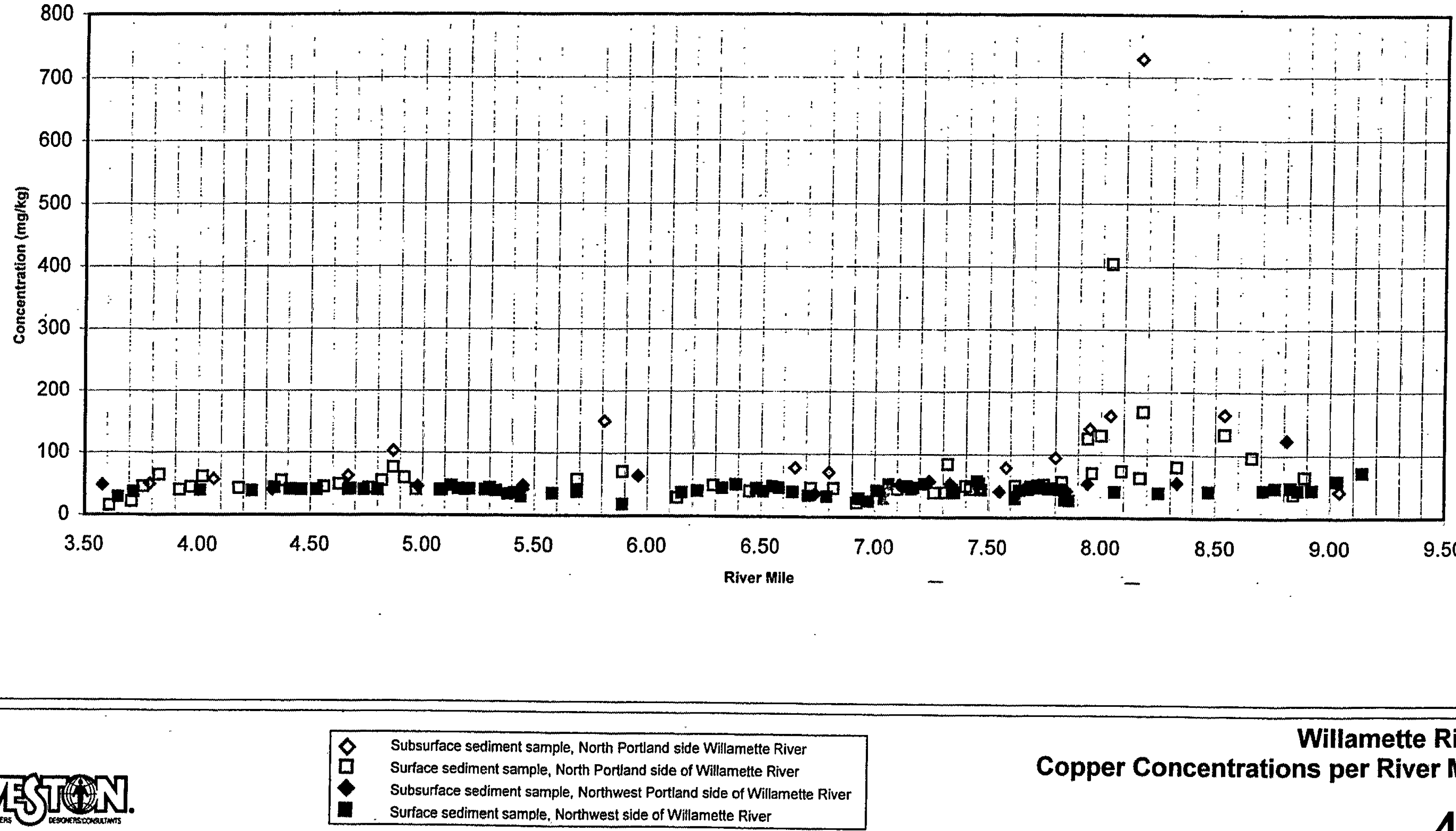
Willamette River
Chromium Concentrations per River Mile

Figure
4-3

98-0288.fig

0036



WESTON

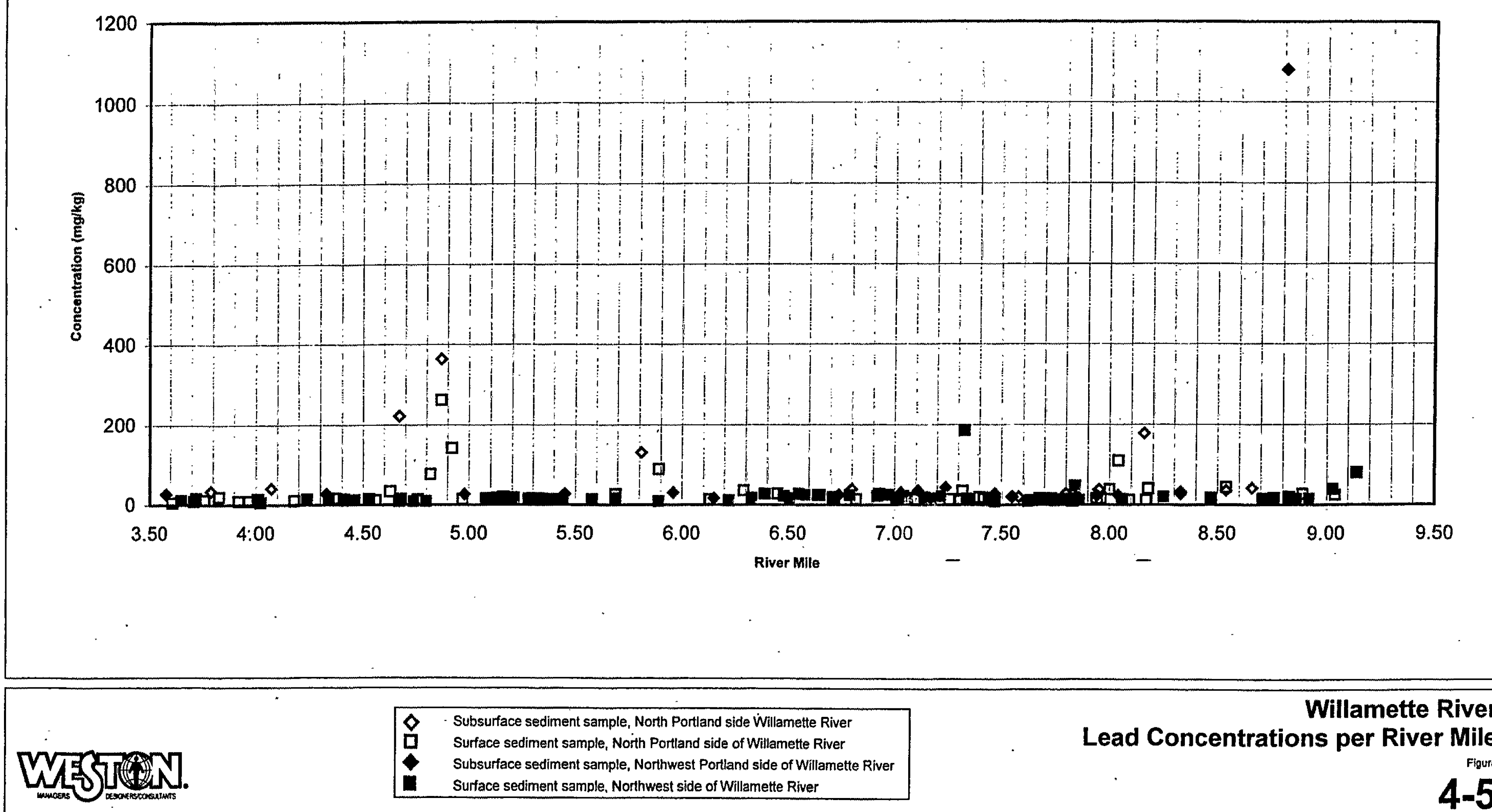
MANAGERS DESIGNERS/CONSULTANTS

Willamette River
Copper Concentrations per River Mile

Figure
4-4

98-0288.fig

0037

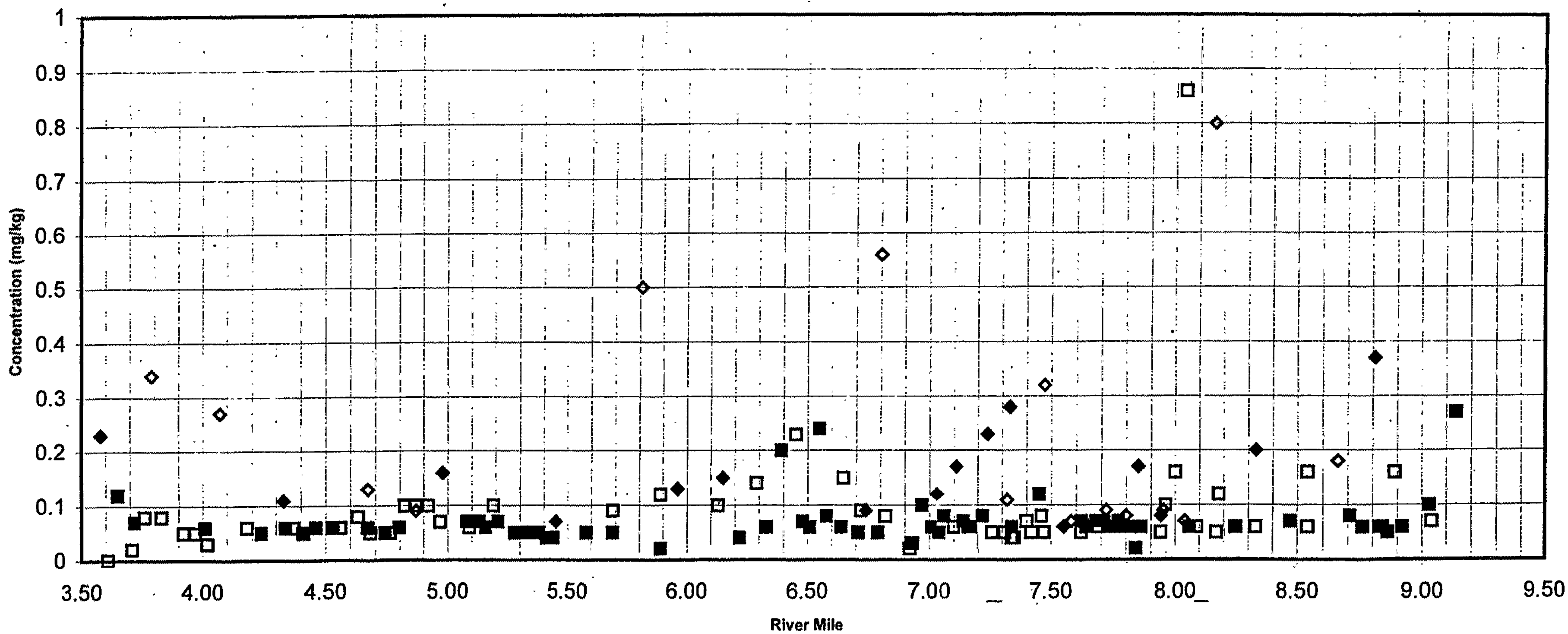


Willamette River
Lead Concentrations per River Mile

Figure
4-5

98-0288 fig

0038



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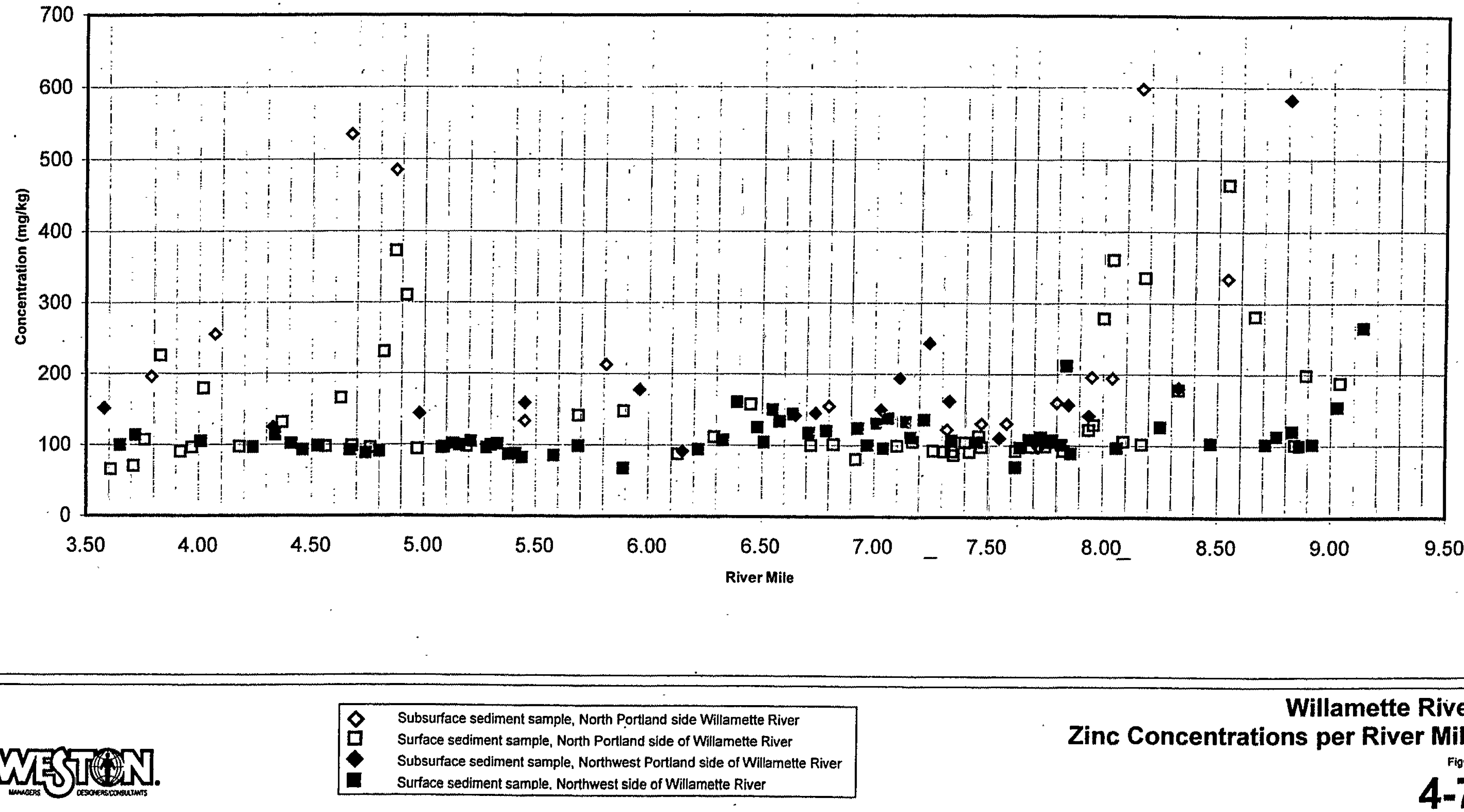
Willamette River
Mercury Concentrations per River Mile

Figure
4-6

98-0288.fig

0039



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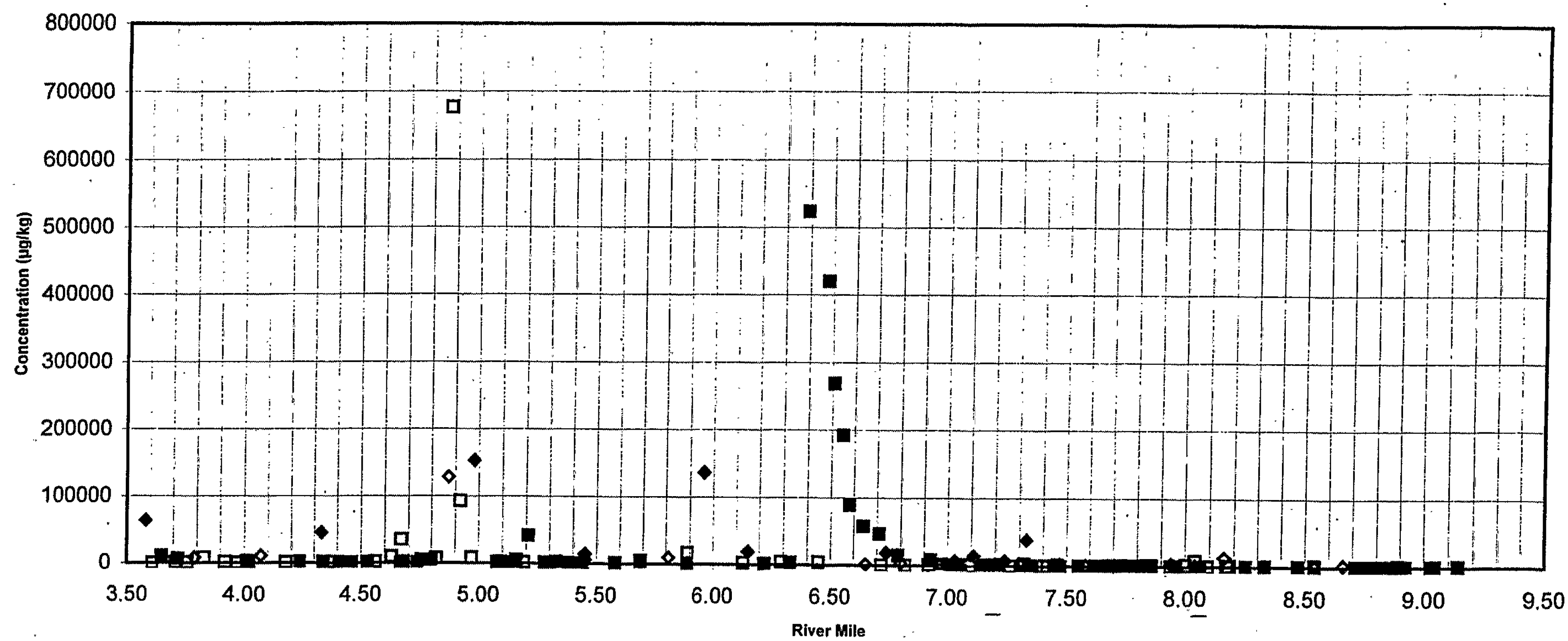
Willamette River
Zinc Concentrations per River Mile

Figure
4-7

98-0288 fig



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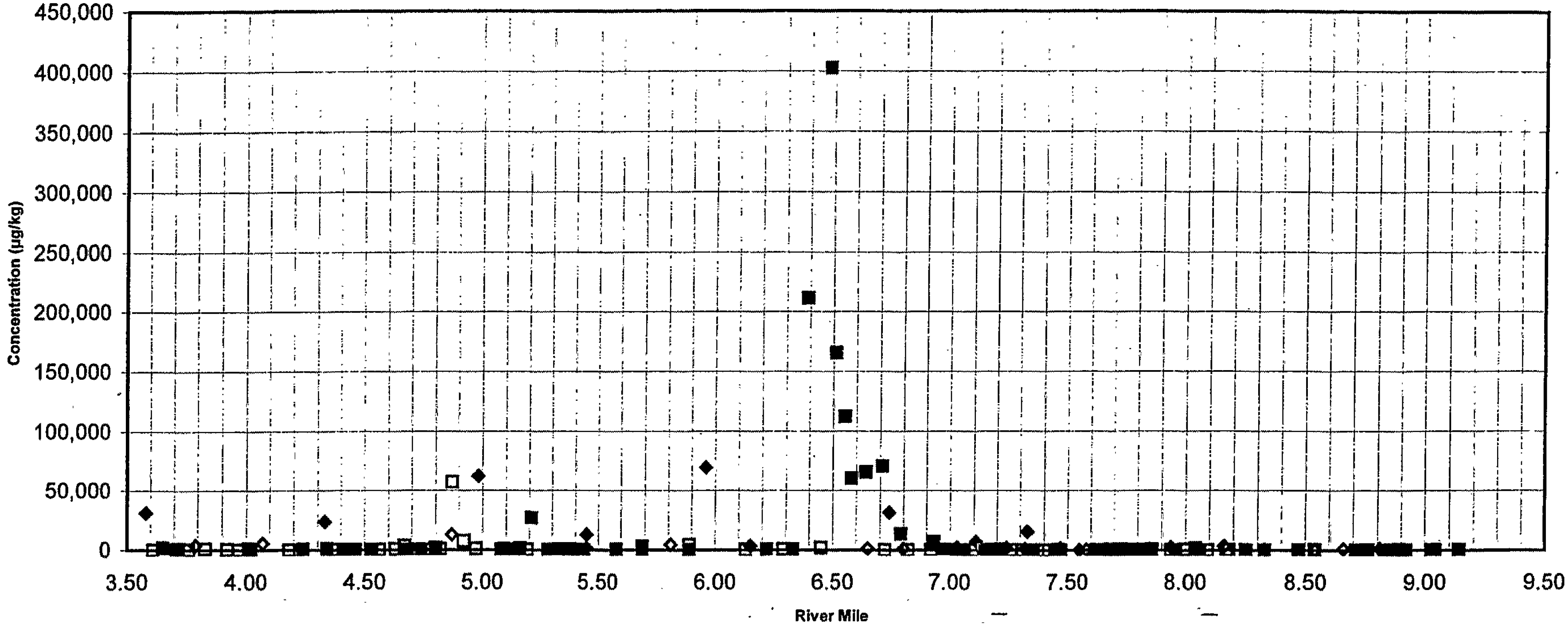
Willamette River
Total HPAH Concentrations per River Mile

Figure
4-8

98-0288.fig



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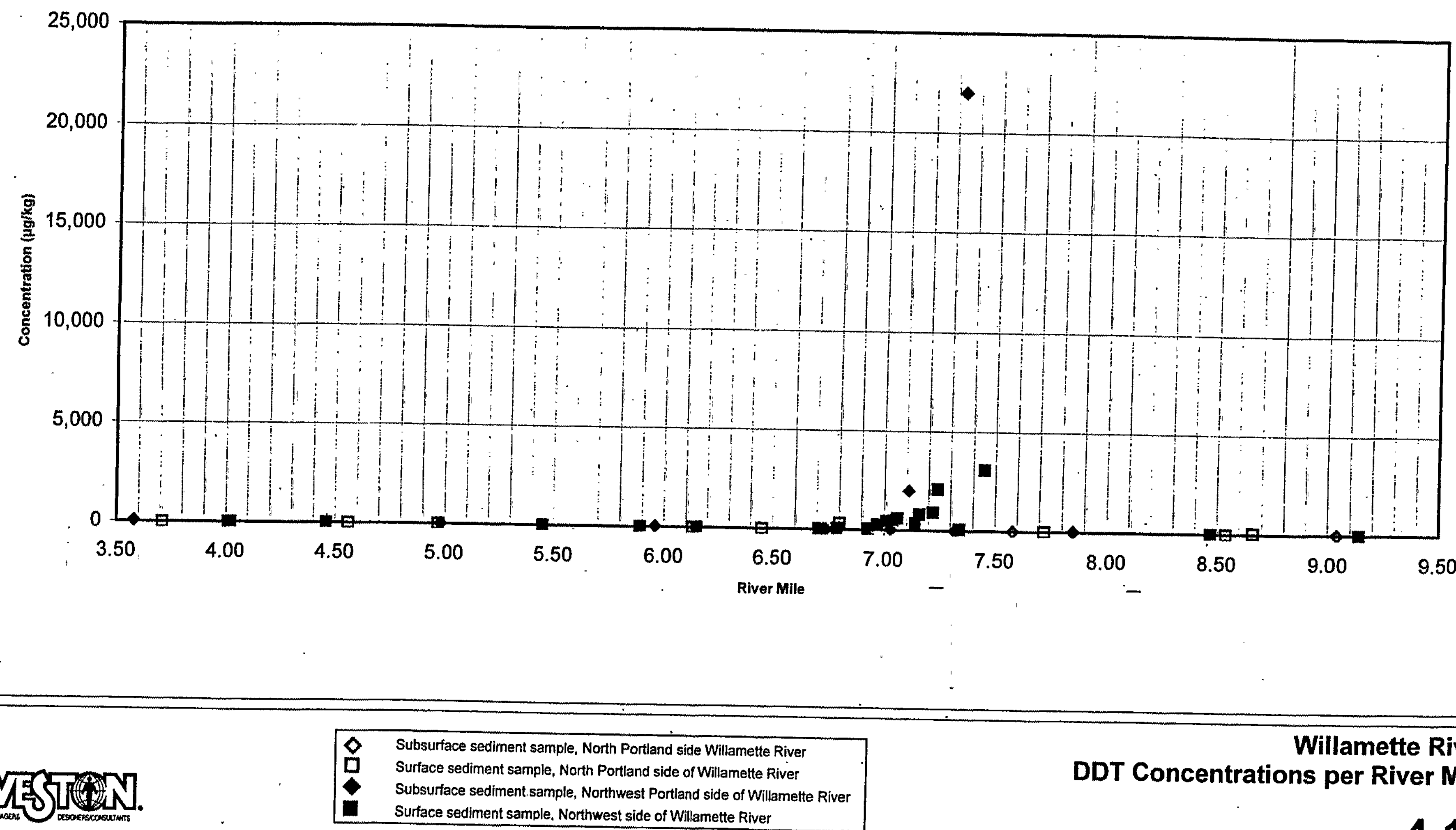
Subsurface sediment sample, North Portland side Willamette River
Surface sediment sample, North Portland side of Willamette River
Subsurface sediment sample, Northwest Portland side of Willamette River
Surface sediment sample, Northwest side of Willamette River

Willamette River
Total LPAH Concentrations per River Mile

Figure
4-9

98-0288.fig

0042



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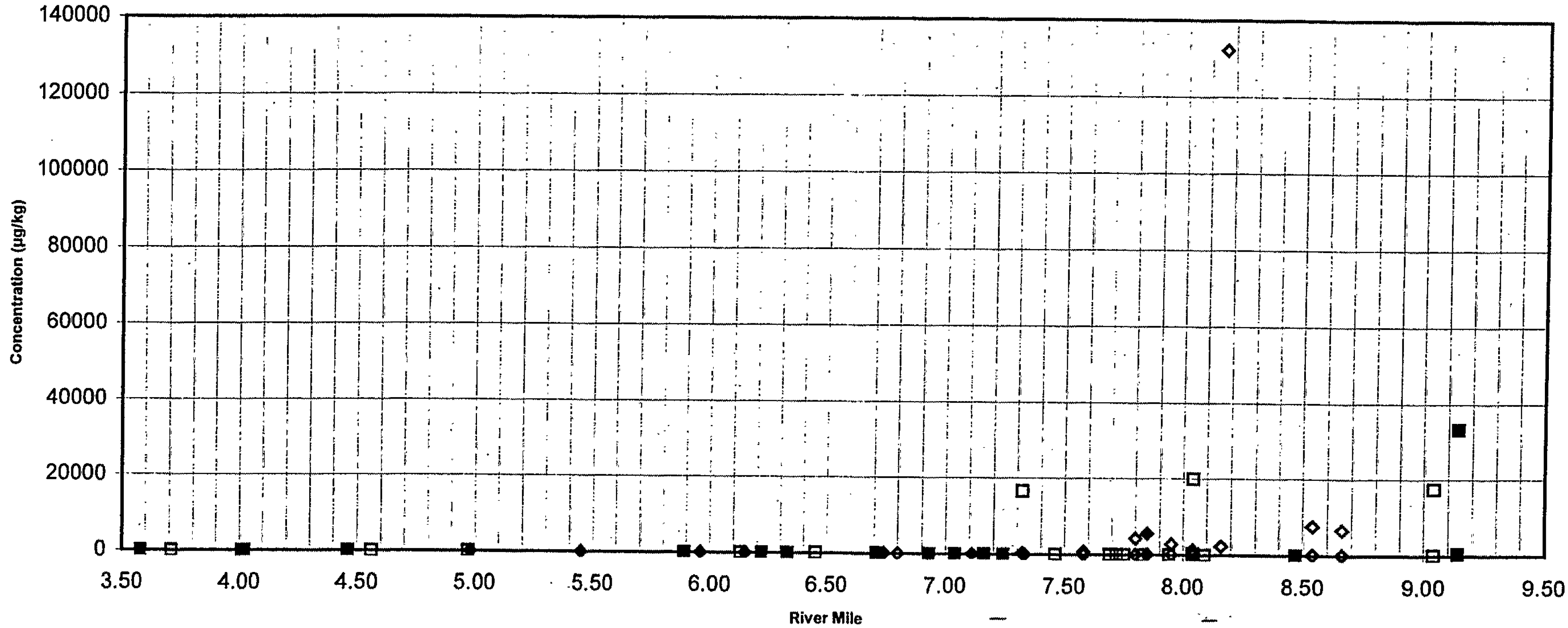
Willamette River
DDT Concentrations per River Mile

Figure
4-10

98-0288 fig

0043



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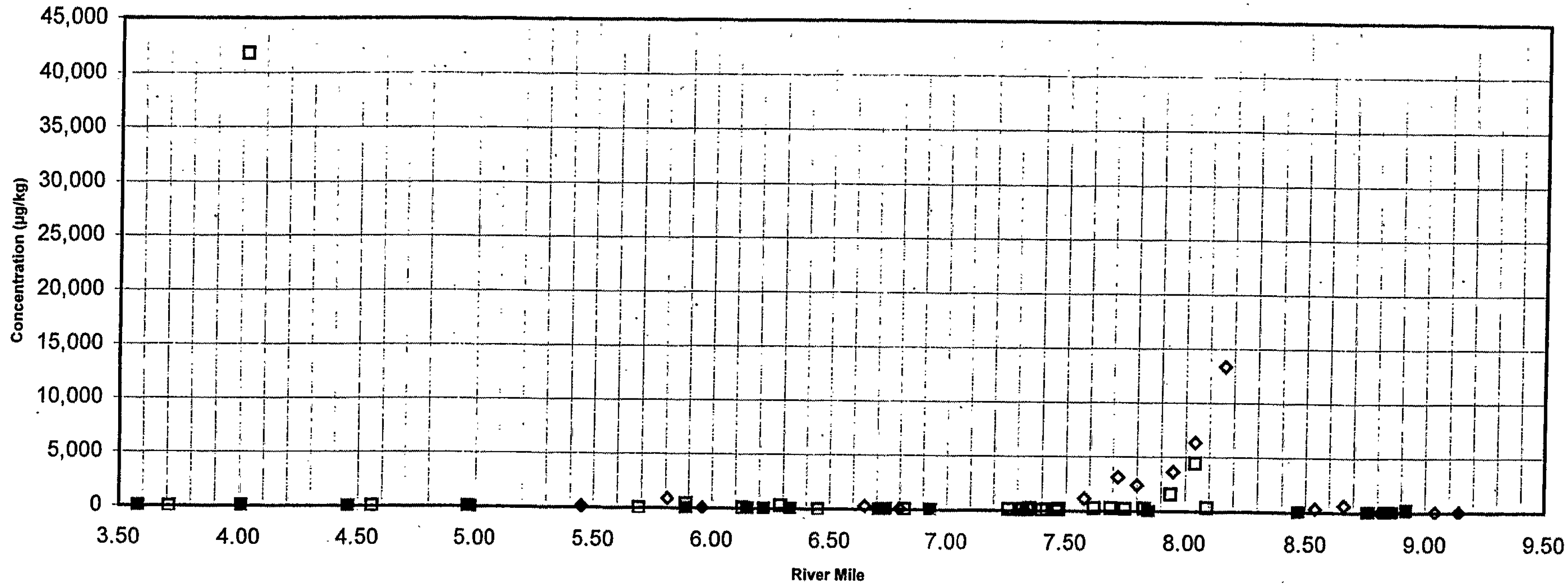
Willamette River
Total PCB Concentrations per River Mile

Figure
4-11

98-0288.fig

0044



Subsurface sediment sample, North Portland side Willamette River
Surface sediment sample, North Portland side of Willamette River
Subsurface sediment sample, Northwest Portland side of Willamette River
Surface sediment sample, Northwest side of Willamette River

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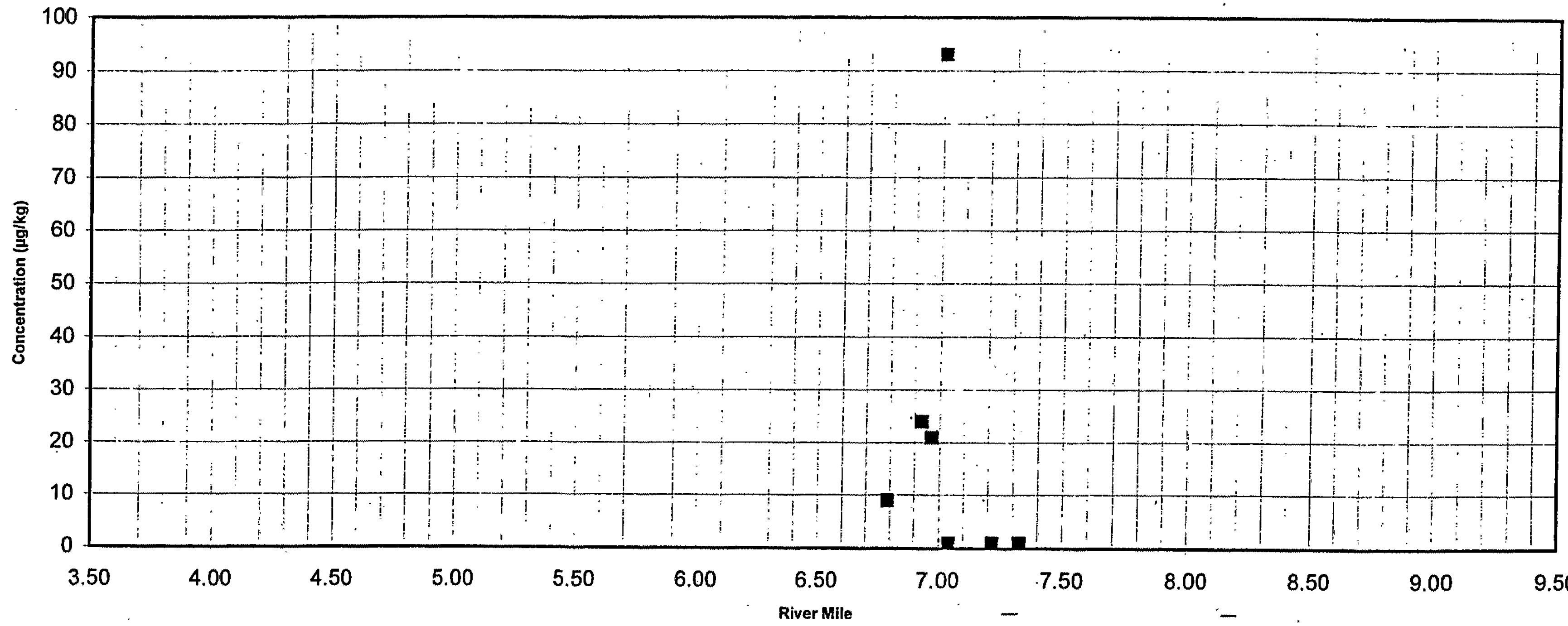
Willamette River
Sediment TBT Concentrations per River Mile

Figure
4-12

98-0288.fig

0045



Subsurface sediment sample, North Portland side Willamette River
Surface sediment sample, North Portland side of Willamette River
Subsurface sediment sample, Northwest Portland side of Willamette River
Surface sediment sample, Northwest side of Willamette River

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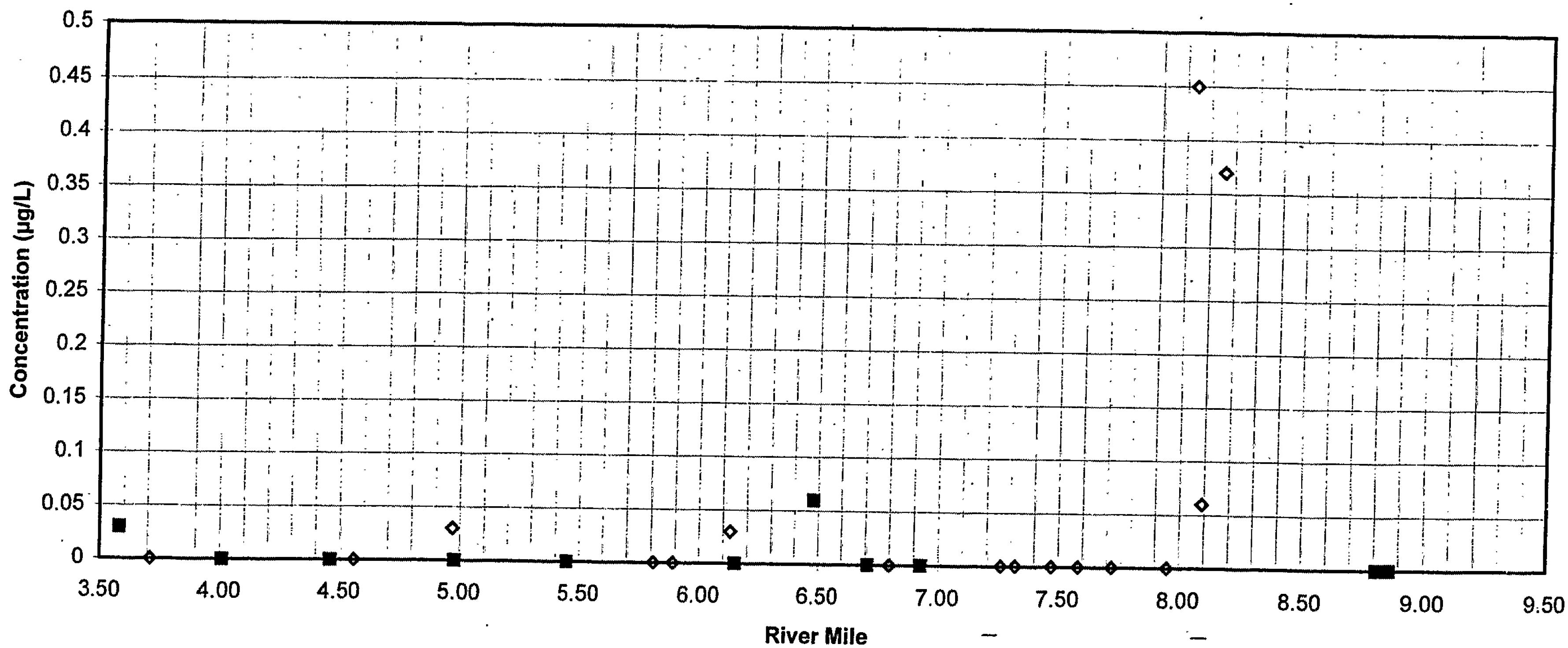
Willamette River
2,4-D Concentrations per River Mile

Figure **4-13**

98-0288.fig

0046



Subsurface sediment sample, North Portland side Willamette River
Surface sediment sample, North Portland side of Willamette River
Subsurface sediment sample, Northwest Portland side of Willamette River
Surface sediment sample, Northwest side of Willamette River

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Willamette River
Sediment Porewater Concentrations per River Mile

Figure
4-14

98-0288.fig

0047